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PHYTOPATHOLOGY

VOLUME VI NUMBER 4

AUGUST, 1916

POTATO WILT AND TUBER ROT CAUSED BY FUSARIUM EUMARTII

ROYAL J. HASKELL

WITH THREE FIGURES IN THE TEXT

Many attempts have been made by different workers to connect various potato tuber rots, caused by species of Fusarium, with a pathological condition of the top of the potato plant. As a result of these efforts[1] only two species of Fusarium, *F. oxysporum* Schlecht. and *F. trichothecioides* Wr., have been found to produce wilt, and even in these cases the positive proof is meager or entirely lacking. It is the object of this paper to report the pathogenicity of a species of Fusarium on the vines, as well as on the tubers, of the potato plant and to furnish the evidence on which this conclusion is based.

During the winter of 1914 affected potatoes were received from Lodi, New York. Some of the diseased tubers showed a sunken, wrinkled, dry, stem-end-rot of varying diameter while others gave only a slight indication of rot around the point of attachment of the rhizome. When specimens of this latter type were cut across near the base, however, browning in the region of the ring of fibro-vascular bundles was evident. This discoloration extended to various depths in the tuber sometimes affecting the whole fibro-vascular ring but more often involving only separate portions of it. The cells in the vascular ring showed the greatest discoloration and degeneration but the parenchyma on either side of the more badly affected areas usually appeared brown, yellowish, or water-soaked. When potatoes with the dry, sunken, stem-end-rot were cut,

[1] Manns, T. F. The Fusarium blight and dry rot of the potato. Ohio Agr. Exp. Sta. Bul. 229: 299–336, pls. 1–15. 1911.

Jamieson, C. O., and Wollenweber, H. W. An external dry rot of potato tubers caused by Fusarium trichothecioides Wollen. Jour. Washington Acad. Sci. **2**: 146–152. 1912.

it was found that the rot was not confined to the bundles but involved the entire basal end.

The isolation of the causal fungus was made as follows: The tubers were first disinfected in corrosive sublimate solution (1–1000) for ten minutes after which they were partly cut through with a flamed scalpel, and then broken open. Plantings of diseased tissue from affected bundles on the broken surface were made into poured plates of a potato-agar medium. From 60 per cent of the plantings there developed a species of Fusarium having a pale olive-buff color on the medium used.

FIG. 1. Plant on the left inoculated with *Fusarium eumartii*, the one on the right is a check. Photograph taken 77 days from time of planting and 44 days after inoculation. The stem of the inoculated plant is rotted through below the ground.

As this Fusarium appeared to be different from any before reported, a culture was sent to Dr. C. D. Sherbakoff at the Florida Experiment Station. An examination by him showed it to be unlike any of those listed in his Fusaria of Potatoes and later a comparison of this organism with *Fusarium eumartii*, recently described by Carpenter,[2] brought out the fact that the two were identical. The following brief description and results of the comparative study are kindly furnished by Dr. Sherbakoff:

"Conidia slightly curved only in the upper third of their length and nearly straight in the lower two-thirds, seldom attenuated toward the

[2] Carpenter, C. W. Some potato tuber-rots caused by species of Fusarium. Jour. Agr. Research **5**: 183–209, pls. A–B, 14–19. 1915.

lower end as is the case with *F. martii* Ap. & Wr.; occupying, in type, a position intermediate between *F. martii* Ap. & Wr. and *F. coeruleum* (Lib.) Sacc., more resembling the latter type; 5-septate conidia always

FIG. 2. Stems of plants having the appearance of the diseased plant in figure 1 but at a slightly later stage.

greatly predominating over conidia of other septations, sometimes reaching 100 per cent."

There follows Dr. Sherbakoff's comparison of *Fusarium eumartii* strain No. 3551 received from Mr. Carpenter, and *Fusarium eumartii* strain *P* which was used in this work.

FIG. 3. Above, external appearance of affected potatoes when dug. The stem-end lesion may be sunken and shriveled, or not, depending on conditions; below, internal appearance of tuber affected as is the one above on the right.

Cultures on hard, oat-agar, thirty-six days old

1. Strain No. 3551.
   Conidia: 5-septate, up to 100%, 57 x 6 (50–63 x 5.8–6.3)μ
   3- and 4-septate, few
2. Strain *P.*
   Conidia: 5-septate, 95%, 58 x 6 (49–66 x 5.7–6.4)μ

Cultures on bean-pod plugs, twenty days old

1. Strain No. 3551.
   Conidia: 3- and 4-septate, exceptional
   5-septate, 90%, 55 x 6.1 (50–59 x 5.8–7)μ
   6-septate, 10%, 62 x 6.5 (57–69 x 6–7)μ
   7-septate, rare, 66 x 6.8μ
2. Strain *P.*
   Conidia: 3- and 4-septate, 10%
   5-septate, 89%, 57 x 6 (50–65 x 5.7–6.5)μ
   6-septate, less than 1 per cent, 6.3 x 6.1 (60–66 x 59–6.5)μ

Cultures on tomato-stem plugs

1. Strain No. 3551.
   Conidia: 3- and 4-septate, 2%
   5-septate, 96%, 56 x 6 (50–60 x 5.8–6.5)μ
   6-septate, 2%, 61.5 x 6.1 (58–66 x 6–6.5)μ
2. Strain *P.*
   Conidia: 5-septate, 82%, 57 x 6 (50–62 x 5.8–6.5)μ
   6-septate, 12%, 60 x 6.0 (55–70 x 5.8–6.5)μ
   7-septate, few, 65 x 6.2μ

After making sure that the cultures were pure,[3] inoculations of healthy plants were made.

On March 4, 1915 two plants in the greenhouse, four to six inches high, were inoculated by placing mycelium and spores in a small slit in the stem just below the level of the ground. Two similar neighboring plants were injured in the same way but no inoculum was introduced. At the end of twenty days both inoculated plants showed marked evidence of infection. On one the upper leaves were flaccid and the lower leaves were dead or dying, especially on the side where the inoculum was placed. The other plant showed a yellowing and wilt of the lower leaves at this time. Both stems below ground were found to be nearly rotted through.

Thirty-seven days after inoculation both plants were dead, broken and fallen over, with the fungus fruiting on the stem near the soil. The

[3] Cultures were obtained from the growth of a single spore by pouring dilution plates of clear agar and locating the spores with the low power of the microscope. The location was marked with ink and after germination bits of mycelium on agar were transferred to tubes.

two check plants remained healthy and continued to grow until they were taken up some time later.

Some of the small tubers which were formed on the diseased plants were found to be affected with an internal rot which in one case extended nearly through the potato. A single attempt to reisolate the Fusarium from these potatoes was not successful.

In order to try inoculations on a larger scale and under natural conditions, about fifty plants growing out-of-doors were inoculated during the summer of 1915. This was accomplished, for the most part, by injecting spores of the pathogene with a hypodermic needle into that part of the stem below ground. In this way only a very slight wound was made.

Out-of-doors, as in the greenhouse, the symptoms on the top began to appear about twenty days after inoculation. In the majority of cases this took the form of a leaf-burn, especially of the lower leaves, but in some instances the disease was manifested by a rolling or slight rosetting of the leaves. In the last stages the leaves wilted, followed soon after by death (fig. 1). At no time did these plants suffer from drought as there was an abundant amount of rain all summer. It is probable that the wilt symptom would be much more prominent in a dry season.

At the point of inoculation a dry rot developed which in time involved much of the stem below ground (fig. 2). Often the rot extended upward in the cortex, sometimes as far as the lower branches. From the cortical tissue the fungus gained entrance to the vascular elements within which it spread up and down the stem and into the tubers. Sometimes the inoculated stalks showed brown flecks in the pith high up in the plant, particularly at the nodes.

When the hills were dug it was noticed that several of the potatoes from inoculated plants had a dry, stem-end-rot and vascular browning similar to that from which the Fusarium was originally isolated (fig. 3). None of the tubers from the numerous check plants, or from any other plants in the field, was thus affected. In addition to this the yield from the inoculated hills was much lower than that from the checks. Ten neighboring hills of the inoculated set yielded thirty-four tubers while ten adjoining check hills in the same row gave one hundred and seven potatoes of marketable size.

The Fusarium was reisolated from some of the tubers borne on the inoculated plants and was found to be identical with the original strain. To make positive of this, it was again inoculated into stems and found to cause the characteristic stem-rot and consequent death of the plant.

In order to test the true parasitic nature of this fungus on the potato top, sterilized soil in pots was inoculated with a flask culture of the organism and sprouted potatoes planted. Again, after about twenty days,

some of the plants began to wilt and die, and an investigation of the parts below ground showed that the main stem, some of the roots, and even some of the young potatoes had become affected directly from the soil.

On some of the tubers of inoculated plants the writer has noticed cases of outside injury which appears as a dry rot in spots on the surface, particularly at the "eyes," and it is believed that this may be one phase of the disease.

Potato tubers have been inoculated with this species of Fusarium and the results obtained correspond with those of Carpenter,[4] in establishing the fact that this fungus is a wound parasite. In table 1 are given the results obtained.

TABLE 1

Results of inoculation of potato tubers with Fusarium eumartii in 1915

ORGANISM	DATE OF INOCULATION	NUMBER OF TUBERS	AGE OF TUBERS	INCUBATION	PER CENT OF ROT
F. eumartii	March 28	4	old	26 days	100
	June 22	4	old	34 days	100
	October 13	4	new	30 days	100
	December 5	2	new	16 days	100

In all these cases there was a dry, sunken rot, produced about the point of inoculation, from two to five centimeters in diameter. The Fusarium was fruiting on the sunken surface, and the rot extended deep into the tuber in every case.

CONCLUSIONS

1. The organism is morphologically identical with *Fusarium eumartii* Carpenter.

2. As a result of pure culture inoculations, both in the greenhouse and out-of-doors, on sterilized and unsterilized soil, it is evident that *Fusarium eumartii* may produce both a wilt of the potato vine and a rot of the tuber.

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[4] Carpenter, C. W. Some potato tuber-rots caused by species of Fusarium. Jour. Agr. Research **5**: 183–209, pls. A-B, 14–19. 1915.

THE MOSAIC DISEASE OF TOMATOES AND PETUNIAS

H. A. Allard

With Two Figures in the Text

In 1908, Clinton,[1] working in Connecticut, first proved conclusively that the mosaic disease of tobacco is communicable to healthy tomato plants, and vice versa. This is perhaps the first definite evidence adduced to indicate that the infectious mosaic disease of tomatoes is identical with the well-known mosaic disease affecting the tobacco plant.

The writer's experiments also show that the mosaic disease of tobacco is readily communicable to the tomato plant and produces well-marked changes in the structure and appearance of the leaves. A more or less pronounced mottling of the leaves, characteristic of mosaic alone, is generally indicated. In some phases of the disease, the leaves are so completely dwarfed and misshapen as to bear no resemblance whatever to a normal leaf. The nature and intensity of the symptoms of mosaic depend, to a considerable degree, upon the variety of tomato affected. The larger leaved sorts show all phases of the disease in a most pronounced form. On the other hand, the finer foliage of the cherry-fruited sorts may exhibit the most attenuated symptoms of the disease.

The Wisconsin Agricultural Experiment Station[2] in 1911 reported that the cherry and peach types of tomatoes were naturally resistant to the mosaic disease, and that crossing either of these with the variety Earliana gave strains resistant to the disease.

Although many distinct varieties have been observed and tested, the writer has found no variety of tomato immune to the mosaic disease of tobacco. The peach and the cherry varieties do not appear to show greater immunity than others, although it should be said that the finer foliage of these varieties may show symptoms of a very attenuated character. It is possible that this fact has led to the conclusion that certain varieties are more or less resistant or immune to the disease.

In 1910, Johanna Westerdijk[3] published an interesting account of the

[1] Notes on fungous diseases, etc., for 1908. Connecticut Agr. Exp. Sta. Bien. Rept. **1907–1908**: 857–858.

[2] Tomato breeding experiments. Wisconsin Agr. Exp. Sta. Bul. 218: 20.

[3] Die Mosaikkrankheit der Tomaten. Amsterdam, 1910, 19 p. Mededeelingen uit het Phytopathologisch Laboratorium "Willie Commelin Scholten." Amsterdam 1.

mosaic disease of tomato. She concludes that this disease is infectious to tomatoes but that it is not communicable to tobacco. She is inclined to believe that the development of the disease is greatly dependent upon the intensity of light, and that strong sunlight increases the intensity of the symptoms. She also states that she was unable to communicate the mosaic disease of tobacco to healthy tomato plants by artificial inoculation.

Perhaps the most striking feature of Westerdijk's work is the conclusion that the mosaic disease of the tomato, in striking contrast to the mosaic disease of tobacco, is carried to the next generation of plants through the seed. Westerdijk's results in some respects are radically different from the writer's experiences with the infectious mosaic of tobacco and tomatoes. From the nature of these discrepancies one is led to wonder if the diseases investigated by Westerdijk are in reality identical with the mosaic diseases investigated by the writer.

EXPERIMENTS WITH PROGENIES OF MOSAIC-DISEASED TOMATO PLANTS

At the same time that the writer was making a study of the distribution of the virus in tobacco plants and its relation to the progeny of such plants, parallel experiments were performed with tomatoes and petunias affected with the same disease. As the following data show, the development of the disease in these plants is similar in all respects to the development of the disease in the tobacco plant.

In September, 1913, twenty-four plants were grown from seed of very badly mosaic-diseased tomato plants grown in pots. These seedlings were transplanted to a field where they were allowed to remain until full grown. At this time they averaged eighteen to twenty inches in height and every plant remained free from mosaic.

In a second experiment, seed of lot *A* from several large, badly mosaic-diseased plants were sown in a two-feet-square box, July 12, 1913. On August 2, 158 plants of this lot were transplanted to rich soil on a side bench in the greenhouse kept free from insects. On September 10, these plants averaged two to three feet in height and were full of blossoms and small, green tomatoes. Not a plant developed mosaic.

On July 15, eighty additional plants of the original lot *A* were transplanted to five inch pots and allowed to remain. On September 9, the plants, averaging two feet in height, were in full bloom and free from mosaic.

Fifty seedlings of the same lot were transplanted to the middle bench on August 2. These plants averaged eighteen inches to two feet in height and were in full bloom on September 9. None developed mosaic.

Ninety-five plants of the original lot were also allowed to grow undisturbed in the box in which they were germinated. These plants were in full bloom on September 8, and all remained free from mosaic.

In addition to these tests, thirty-four or thirty-five plants, from the original lot *A*, when young, were transplanted to the field. Many of these plants became diseased with mosaic. Another series of the same lot *A* was inoculated with the infective principle of mosaic. All these developed the disease ten to twelve days later. It may be stated here that the plants which were transplanted to the field in the immediate vicinity of a field of badly mosaic-diseased tobacco plants, became infested with aphids and flea beetles from the start. It is probable that these insects were responsible for the occurrence of the disease in these plants, since earlier investigations by the writer has shown that insects may become active disseminators of the virus of mosaic disease of tobacco.[4]

In a third experiment, 155 seedlings were grown from mixed seed of several large, mosaic-diseased tomato plants in pots. The seeds were sown July 9, and the young plants transplanted to a bed in the greenhouse August 2. On September 9, the plants averaged eighteen inches to two feet in height and were in full bloom. Throughout the experiments these plants were large, bushy and vigorous, and all remained free from mosaic.

In a fourth experiment, a mixed lot of seed *B* from several badly mosaic-diseased tomato plants, grown in pots, was sown September 15, 1913. These seedlings were grown as follows:

Thirty-two seedlings were transplanted to box No. 1, 12 inches square, September 30.

Thirty-two seedlings were transplanted to box No. 2, 12 inches square, September 30.

Thirty-six seedlings were transplanted to box No. 3, 12 inches square, September 30.

Thirty-six seedlings were transplanted to box No. 4, 12 inches square, September 30.

Fifty-two seedlings were transplanted to a bed in the greenhouse September 30.

Sixty-five seedlings were allowed to remain in the original box in which they were germinated.

These plants were allowed to grow unscreened in the greenhouse. A few aphids and an occasional flea beetle were noted on some plants. An examination of the several lots November 12 gave the following results:

[4] The mosaic disease of tobacco. U. S. Dept. Agr. Bul. 40. January, 1914.

Box No. 1, plants 18 to 20 inches high, budded or in bloom, one mosaic-diseased plant.

Box No. 2, plants 18 to 20 inches high, budded or in bloom, two mosaic-diseased plants.

Box No. 3, plants 18 to 20 inches high, budded or in bloom, no mosaic-diseased plant.

Box No. 4, plants 18 to 20 inches high, budded or in bloom, no mosaic-diseased plant.

Plants in the bed (52) averaged two feet in height, just blooming, one mosaic-diseased. Plants in the orignal box (65) averaged 18 to 20 inches in height, ready to bloom, none diseased.

In this test only four plants of the 253 grown to the blooming stage developed mosaic. There is every reason to believe that these plants developed the disease as a result of late, accidental infection, since symptoms did not appear until they were well toward maturity.

In a fifth test, 250 seedlings were grown from mixed seed of several badly mosaic-diseased tomato plants grown in beds in the greenhouse at Arlington, Virginia, during the season of 1913. The seed was sown on February 11, 1914. On February 27, the seedlings were transplanted as follows:

Fifty plants in ten rows of five each were transplanted to plot No. 1.

Fifty plants in ten rows of five each were transplanted to plot No. 2.

Fifty-eight plants were transplanted to 6-inch pots.

Twenty-two plants were transplanted to 3-inch pots.

Seventy plants were allowed to remain where germinated.

With a needle the fifty plants in plot No. 1 were inoculated with the virus of tobacco mosaic at many points on the leaves on February 27, March 3, 7 and 9. The twenty-two plants transplanted to three-inch pots were inoculated in the same manner on February 27 and March 3. The first inoculation of February 27, was made while the plants were in the cotyledon stage. Symptoms began to appear in nearly every plant ten to twelve days later. When examined on April 22, the plants were in full bloom and every inoculated plant in plot 1 and those in the three-inch pots had developed mosaic. Aside from these not a single plant in the uninoculated lots developed mosaic. From these tests it is safe to conclude that the infectious principle of mosaic did not exist in these plants prior to inoculation.

Although in the writer's experience no evidence of embryonic infection in the seed has ever been obtained, it would not be safe to assert that this never occurs. However, all evidence at hand indicates that it must be of very rare occurrence.

OCCURRENCE OF THE INFECTIVE PRINCIPLE IN THE FRUITS

Experiments have shown that the infectious principle of mosaic disseminates itself to all parts of affected tomato plants. The sap of the roots is quite as infectious as that of diseased leaves. The mature, healthy-appearing leaves of affected plants in which the disease has been long established, likewise carry the virus. Extensive experiments have shown that the juice of fruits at all stages of their growth carry the virus of the disease.

The following experiments demonstrate the presence of the virus in the green and ripe fruits of affected tomato plants as well as in the foliage.

On May 20, ten plants were inoculated with the extracted juice of a green tomato fruit from mosaic plant *A*. Four plants showed mosaic on May 28. Ten plants, as a control, were inoculated May 20 with the juice of a green tomato from a healthy plant. No mosaic developed.

On May 20, ten plants were inoculated with the extracted sap of a green tomato fruit from mosaic-diseased plant *B*. Nine plants showed mosaic on May 28 and 29. Ten similar plants inoculated on the same date and in the same way with the sap of leaves of the same plant *B* gave four plants with mosaic on May 28. Ten similar plants, as a control series, were inoculated on May 20, with the extracted juice of a green, healthy tomato fruit. No mosaic developed.

On June 2, ten plants inoculated with the extracted juice of a fully ripened, red tomato from mosaic-diseased plant *B* in the preceding tests. On June 10 two plants showed mosaic. Ten plants inoculated on the same date with sap of the leaves of plant *B*, on June 10 gave six plants with mosaic. As a control, ten plants were inoculated on June 2, with the juice of a green fruit from a healthy plant. No mosaic developed.

On June 6, ten plants were inoculated with the extracted sap of a green tomato from mosaic-diseased plant *C*. On June 11 five plants had developed mosaic. On June 6, ten plants were inoculated with the sap of leaves from the same plant *C*. On June 11 six plants showed mosaic. Of ten control plants inoculated on June 6 with the sap of a green fruit and leaves of a healthy plant, none developed mosaic.

On June 24, ten plants were inoculated with the extracted juice of a ripe tomato from mosaic-diseased plant *D*. On June 30, five plants had developed mosaic. Of ten controls inoculated with the juice of a ripe tomato from a healthy plant, none developed mosaic.

All tests with the extracted juice of green and ripe fruits of mosaic-diseased plants have shown that the virus of the disease is disseminated throughout the fruits as well as the foliage and roots. Although ripe, red fruits likewise contain the virus, experiments seem to indicate that

inoculations in some instances are, perhaps, less certain when such fruits are used than when green ones are used. However this may be, the virus sooner or later becomes distributed more or less abundantly in the fruits, both green and ripe.

Although the virus is present in the fruit, it appears to produce no appreciable change in the development of the usual red color in ripening fruit, similar to the mottling produced in the pink or red blossoms of tobacco plants. The yellow color of the blossoms of tomato plants likewise does not seem to be modified by the disease.

FIG. 1. At left healthy tomato plant; at right mosaic-diseased tomato plant of same age obtained by inoculation from mosaic-diseased tobacco.

INCUBATION PERIOD OF THE VIRUS

As in tobacco, the incubation period of the mosaic virus in tomato plants is greatly dependent upon the age, vigor and growth conditions of the plants. Young, rapidly growing plants show visible symptoms more quickly than old plants. Inoculation experiments with tomato plants at different seasons have given the following results:

Seven good-sized plants, several weeks old, were inoculated with the virus of tobacco mosaic on December 21, 1912. First symptom in fifteen days.

Nine good-sized tomato plants, several weeks old, were inoculated with the virus of tobacco mosaic on June 11, 1913. First symptom in seventeen days.

Seventy-two young tomato plants were inoculated with the virus of

tobacco mosaic on February 27, 1914, while in the cotyledon stage and on several subsequent dates. The earliest symptoms were showing ten to twelve days afterward.

Under conditions favoring rapid growth, visible symptoms of mosaic may appear in young plants inoculated with the virus even more quickly than this. Although the leaves may show marked symptoms of disease when very young, the mottling and distortion frequently becomes less pronounced as the leaves become older. The writer has never known a

FIG. 2. Above, leaves from healthy petunia plant; below, leaves from mosaic-diseased petunia plant obtained by inoculation from mosaic-diseased tobacco, showing dark green swellings along the midrib. Natural size.

mosaic-diseased tomato or petunia plant to recover from the disease. Although visible symptoms may be so slight as almost to escape notice, the virus of mosaic is still abundantly present in the plant. Under these conditions, a renewal of growth by cutting back brings a renewed expression of symptoms coincident with the growth of new shoots. Experiments have shown that healthy tomato or petunia plants may be cut back indefinitely without producing mosaic, provided accidental infection is prevented by thorough methods of sterilization and the exclusion of all insect carriers.

In comparison with the same disease obtained by inoculation with the virus of mosaic-diseased tobacco, tomato or petunia plants inoculated with the virus of other solanaceous plants affected with the mosaic disease of tobacco, show no appreciable difference in the incubation period, character of symptoms, and so forth.

PETUNIA PLANTS AFFECTED WITH THE MOSAIC DISEASE

Experiments with petunia plants affected with the mosaic disease of tobacco have also shown that the virus is present in the roots, foliage, stems, green capsules and corollas of mosaic-diseased plants. Since in tests with the capsules, the entire capsule, including the ovary walls, placenta and seed were macerated together, it is impossible to state whether or not the virus reaches the ovules themselves, as is the case with the mosaic disease of tobacco. The seed appears to develop in such capsules quite as normally and as abundantly as in healthy plants. As is the case with tobacco and tomatoes, the seed of mosaic-diseased petunia plants, in the writer's experience, has always produced healthy plants.

Owing to the smaller, thicker leaves and the less evident vein development, the leaves of mosaic-diseased petunia plants do not usually show the beautiful dark green reticulations and mottlings so characteristic of the mosaic disease of tobacco. The leaves are frequently distorted, crinkled or curled, and show large, irregular, dark green areas along the midrib (fig. 2).

As in the case of tobacco, the blossoms of mosaic-diseased petunia plants also show the effect of the disease, sometimes becoming more or less imperfect or depauperate in some portion of the corolla. The uniform color of the blossoms, more especially the pinks and reds, may be broken into lines and patches, or decreased in intensity. In the petunia, however, the blossoms never show the beautiful mottling so frequently seen in the blossoms of affected tobacco plants.

With the exception of slight variations in the external symptoms it is evident that the mosaic disease of tobacco affects the petunia and the tomato in quite the same manner that it affects the tobacco plant. As in the case of tobacco, the virus is disseminated in all parts of the plant but does not appear to be transmitted to the progeny through the seed.

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NOTES ON AN ARTIFICIAL CULTURE OF RHIZOCTONIA CROCORUM

WILLIAM W. DIEHL

WITH ONE FIGURE IN THE TEXT

In a recent publication Duggar[1] mentions the lack of success that has thus far attended attempts to cultivate the violet Rhizoctonia, *R. crocorum* (Pers.) DC., on an artificial medium. It is thought that a record of its successful culture and of the methods employed together with a preliminary description of its cultural characters might be of some use to those investigators interested. It is of interest in view of the increasing prevalence in America of the disease associated with this fungus.[2]

In the fall of 1914 several unsuccessful attempts were made at cultivating this Rhizoctonia by placing material from the diseased host on petri dish plates of the following media: rice agar, synthetic agar,[3] Thaxter's potato hard agar, and a similar medium using alfalfa-root decoction as a base. No growth of Rhizoctonia was observed, although other mould growths, chiefly species of Fusarium, were in abundance. On November 30, 1914, bits of bark, about five millimeters in diameter, covered with a mesh of violet hyphae, were thoroughly washed in sterilized tap water, then placed upon moist sterilized (steamed) rice in tubes. There developed a cottony mass of mold. Frequent examinations of material from the surface of cultures during two weeks incubation failed to show the presence of a violet mycelium of Rhizoctonia. But in twenty-seven days a pinkish violet color became apparent on the medium. Microscopic examination of this material showed Rhizoctonia-like hyphae with contaminating fungi and bacteria.

[1] Duggar, B. M. Rhizoctonia crocorum (Pers.) DC. and R. Solani Kühn (Corticium vagum B. & C.) with notes on other species. Ann. Mo. Bot. Gard. **2**: 403–458. f. 1–4. S. 1915.

[2] *Rhizoctonia crocorum* (Pers.) DC. was found in Iowa for the first time during the summer of 1914 on the farm of Mr. Charles Lau near Davenport, and reported to Dr. L. H. Pammel by G. R. Bliss.

[3] Synthetic agar: water, 1,000 cc.; dextrose, 100 gm.; peptone, 20 g.; dipotassium phosphate, 2.5 g.; calcium chloride, 0.1 g.; potassium nitrate, 2.5 g.; ammonium nitrate, 2.5 g.; magnesium sulfate, 5 g. This so-called synthetic agar here used is an adaptation of the medium described in Darwin and Acton's Practical Physiology of Plants, 68 (ed. 3.) and of that used by F. V. Rand in Jour. Agr. Res. **1**: 305. Ja. 1914.

To secure the organism in pure culture detached masses of hyphae from the material on rice were placed on petri dish plates of various agar media on January 1, 1915. Growth of a violet Rhizoctonia was obtained only upon plates of "radicicola" agar[4] acidulated with acetic acid. Acidulation was accomplished by adding the correct amount of sterilized acid with a sterilized pipette to the medium at the time of pouring the plate. Ten degrees of acidulation were used: 1.0 to 10., using the scale of the Standard Methods of Water Analysis.[5]

Most satisfactory results were obtained with the medium acidulated to 5. At this reaction the spores of the contaminating Fusarium did not germinate, while the extension of contaminating hyphae was somewhat inhibited, and no bacterial growths developed; yet the Rhizoctonia grew apparently with slight inhibition. From projecting hyphae, March 17, 1915, two cultures on "radicicola" agar were obtained: one a culture contaminated by a single type of Fusarium, the other a pure culture.

The growth of the violet fungus in the culture contaminated by the Fusarium resembled that in the original culture; i.e., in thirty days a violet web of Rhizoctonia and Fusarium hyphae was evident at the surface of the medium. Microscopic examination of the fungus showed hyphae similar to young vegetative hyphae from the diseased host. Violet pigment from the fungus by this time was dispersed through the medium to a depth of about one centimeter. That this pigment came from the Rhizoctonia alone was proved by cultures of the contaminating Fusarium which developed no pigment. Though of slow growth, transfers of this culture to "radicicola" agar have continued with but slightly lessened vitality. Transfers were made on July 22, 1915, to sterile alfalfa-root plugs, made by inserting pieces of alfalfa root over moist absorbent cotton and then autoclaving. The culture tubes were sealed with waxed cotton plugs and incubated for twenty weeks. Various inspections during the first six weeks showed the plugs covered by Fusarium. After twenty weeks incubation the Fusarium growth had subsided, while in some instances from one-half to all of the surface of the medium was covered by the purple-black layer of the Rhizoctonia. The absorbent-cotton plug below the medium was also permeated by the mycelium of the fungus. Microscopic examination of the medium showed the fungus to be present only on and in the cortex and in the central pith of the alfalfa-root plug. This type of growth is almost identical with that of the fungus upon alfalfa roots in the field. But while the culture showed

[4] Radicicola agar: water, 1000 cc.; saccharose, 10 g.; dipotassium phosphate, 1.0 g.; agar agar, 20 g. Lipman, J. G. and Brown, P. E. A laboratory guide in soil bacteriology. 76. 1911.

[5] Report of Committee on Standard Methods of Water Analysis. 106. Ja. 1905.

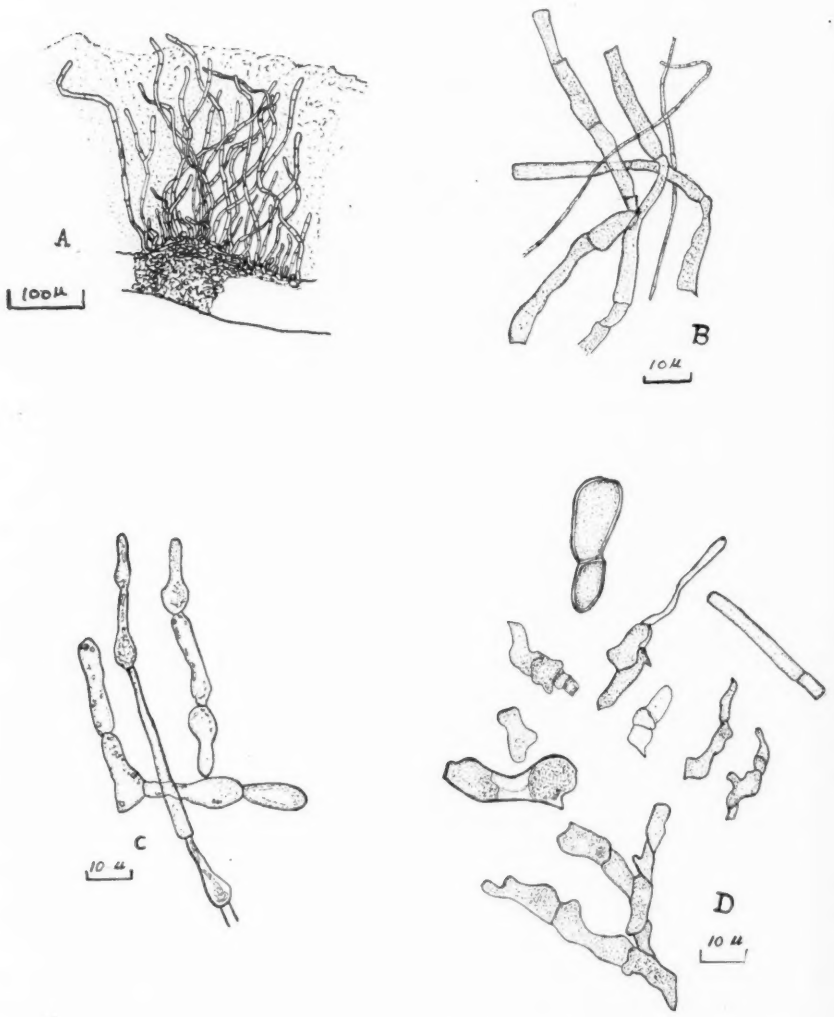


FIG. 1. *A*, Section of cortical surface of an alfalfa-root plug culture of Rhizoctonia with contaminating Fusarium, the latter represented by the shaded area about and between the loose aerial hyphae of Rhizoctonia. *B*, Detail of *A;* the hyphae of small diameter representing the contaminating Fusarium. *C*, Young vigorous hyphae of Rhizoctonia from a Fusarium—contaminated culture on "radicicola" agar. *D*, Hyphae of Rhizoctonia from pure culture.

best growth on "radicicola" agar, sterilized rice, alfalfa root plugs, and synthetic agar, it grew less vigorously upon the following media: rice agar; Thaxter's potato hard agar; alfalfa-root agar (made on the same principle as the potato agar, but using alfalfa roots in place of potato); alfalfa broth (using the same weight of alfalfa leaves and stems as of potato in potato agar and on the same basis without the addition of agar agar); sterilized plugs of elder pith; sterilized plugs of moist absorbent cotton; and sterilized silt loam soil. No growth of Rhizoctonia developed from transfers made at four different times to dextrose broth, dextrose agar, bean agar, and alfalfa agar (made by adding 30 grams of agar agar to the alfalfa broth above described). There was no apparent relation of various temperatures to this culture as exhibited in forty days growth on "radicicola" agar, Thaxter's potato hard agar, and alfalfa-root plugs at 10°, 20°, 22° to 25°, 30°, and 37°C.

The organism in pure culture was grown with some degree of success only on "radicicola" agar. Only two successful transfers have been made—on April 2 and on June 29, 1915. The growth was very slow, barely noticeable in thirty days. The hyphae although somewhat similar in form to those in the contaminated culture, were arranged in a very dense mat; usually these hyphae were similar to those found in sclerotia upon the diseased host. These hyphae, often partially disintegrated, were of a brownish rather than of a violet color; and but slight tendency of the pigment to dissolve in the medium could be observed. The culture tubes were sealed with waxed plugs to prevent further evaporation and were incubated for a period of twenty-four weeks. Of five original transfers to "radicicola" agar the one in which the inoculating material was submersed between the medium and the glass alone showed growth. Several masses of hyphae were grouped in this area. The largest hyphal mass was three millimeters in diameter with a few fine rhizomorph-like strands extending to a distance of two millimeters from the border. In the case of the material incubated for twenty-four weeks upon the surface of "radicicola" agar no increase in the size of the mycelial mass was observed. Microscopic examination of this material showed some new hyphae to be present. Most of them were largely disintegrated indicating a partial autolysis. The latter was true of material incubated for thirty-two weeks upon the bark of sterilized alfalfa-root plugs and upon the other media enumerated in the description of the contaminated culture.

Inoculation of healthy alfalfa plants by placing material from cultures on and within the bark of the roots failed to produce the disease. However, this can hardly be considered as an indication of a lack of virulence in the fungus, since under the same conditions (in greenhouse) no infec-

tion resulted in plants inoculated with fresh material from the diseased host.

That the fungus obtained in culture is considered to be the same as that present on diseased alfalfa is based on the origin of the culture, the morphology of the vegetative hyphae, the character of the contaminated culture on alfalfa-root plugs, and the diffusion of the violet pigment through an acidified agar medium. This last character resembles that of the pigment from hyphae, which is observed by Duggar to dissolve in acidulated water.

The results from artificial cultivation thus far show the violet Rhizoctonia to be of very slow growth upon the media used; and the peculiar cultural characters of this organism indicate that its metabolism, in artificial culture at least, is affected by an accompanying species of Fusarium.

All the cultures described, except where otherwise noted, were kept in a dark closet at room temperature.

The work was done at the instance of Dr. L. H. Pammel and under his direction. Thanks are due to him and to others for suggestions and to Mr. Charles Lau of Davenport, Iowa, who has generously given his time in obtaining material for use.

IOWA STATE COLLEGE
AMES, IOWA

A BACTERIAL DISEASE OF WESTERN WHEAT-GRASS, AGROPYRON SMITHII

Occurrence of a New Type of Bacterial Disease in America[1]

P. J. O'Gara

With Plates IX, X, XI, XII, and XIII

INTRODUCTION

In a note published in *Science*[2] the writer indicated some of the principal facts concerning this disease which was found[3] for the first time in the Salt Lake Valley, Utah, in June, 1915. Later the writer collected specimens in Salt Lake County in the vicinity of Murray. Specimens were also collected in Utah County at a distance of some twenty-five miles to the south of the locality where the first specimens were found. Good material was very abundant. Examination of these specimens showed that the inflorescence was covered with a primuline yellow[4] ooze which hardened on drying. An examination of the yellow slime taken from between the glumes and the floral organs showed that it was composed almost entirely of bacterial organisms. Under humid conditions the ooze was so viscid that the heads of the wheat-grass, when grasped, would stick to the hand. Studies were made of the organism during the season of 1915, the results of these studies being given herewith.

THE DISEASE

The characteristic appearance of the disease is such that it at once suggested a striking similarity to the disease of orchard grass (*Dactylis*

[1] Paper read before the meeting of the American Phytopathological Society, Columbus, Ohio, December 28, 1915. Abstract published in Phytopathology **6**: 98–99. 1916. Some additions have been made to the paper since the original was read.

[2] Science, n. s. **42**: 616–617. October 29, 1915.

[3] The first specimens were brought to the laboratory by Mr. W. W. Jones, botanist in the Department of Agricultural Investigations, American Smelting & Refining Co.

[4] Ridgway, Robert. Color Standards and Nomenclature, 1912 edition. All references to color made in the text refer to this author.

glomerata L.) which was discovered by Rathay[5] and which has been given further study by Dr. Erwin F. Smith.[6] Generally, affected plants are somewhat dwarfed but the most striking characteristic of the disease is the presence of enormous masses of surface bacteria which form a primuline yellow ooze or slime which produces layers between the stem and the upper sheath and between the glumes of the inflorescence. The floral organs are also extensively occupied by the organism. The bacterial ooze also collects on the outer or exposed surface of the glumes and sheaths in globules which, on drying, become hard and brittle. These globules, on weathering, become orange rufous and if held to the light have the appearance of particles of resin. This hardened slime dissolves readily in water, producing a milky appearance. Knee-shaped bendings are often produced in the stem just above the upper node and these often protrude through the sheath. This phenomenon usually occurs when the space between the upper internode and its surrounding sheath is occupied by a deep layer of the primuline yellow bacterial slime. The organism does not penetrate into the tissues until some time after it has covered the surface. It is later found in the substomatic chambers and in the intercellular spaces, but it has not been found occupying the cells. The infected inflorescence rarely ever produces normal, germinable seeds. Thousands of infected spikelets have been examined and in no case have fertile seeds been found in them.

In so far as the writer has been able to determine, this disease of western wheat-grass has not been heretofore reported in the United States. Previous to June, 1915, it had not been observed by anyone in the Salt Lake or Utah Valleys and it is therefore presumed that the disease is a new one. Several common names have been suggested for this disease but the one which seems to be the most satisfactory is the *yellow gum disease* of western wheat-grass.

Whether or not the disease is of any economic importance remains to be seen. It is well known that western wheat-grass propagates itself largely by means of root stocks and the production of seed is therefore of less importance than it otherwise would be. However, the food value of the plant is usually lessened in a certain degree inasmuch as seed is not formed where the inflorescence is attacked. Furthermore, the plants are more or less dwarfed by reason of the early attack of the organism. It has been stated that western wheat-grass does not usually produce an

[5] Rathay, Emerich, Über eine Bakteriose von Dactylis glomerata L. Sitzber. Wiener Akad., Abt. 1, **108**: 597–602. 1889.

[6] Smith, Erwin F. A new type of bacterial disease. Science, n. s. **38**: 926. December 26, 1913.

Bacteria in relation to plant diseases, Vol. III, August 4, 1914.

abundance of matured seed. However, the writer has had occasion to examine non-infected areas for the purpose of making comparison as to the quantity of seed produced. In the Salt Lake and Utah Valleys fertile seeds are generally present in considerable amount in healthy plants, whether they are found growing in the richer, moist soils of the valleys or higher up on the dry, unirrigated foot-hills.

Plants affected with the disease are found in the open and this is in striking contrast to the disease of orchard grass discovered by Rathay, where only shaded plants were found to be infected. The same amount of infection was found in the more moist soils as in the dry, unirrigated soils so that the habitat of the host plant does not seem to have any particular bearing on the disease. This point, however, demands further observation.

Careful examination of many other species of grasses has not been rewarded with the finding of a similar disease. In stands of mixed grasses the western wheat-grass was the only one found to be infected. Whether the organism is pathogenic to other species of wheat-grass is not known. Owing to the fact that other work prevented the writer from carrying out certain experiments little is known as to the manner of natural infection. It is not known how the organism enters the plant, but it is possible that it is carried by insect agencies. The matter of artificial infection will not be discussed here.

A white organism, which has not been given careful study, has been found to be associated with the yellow organism. In most platings the white organism has appeared but always in very small numbers. The association of the white organism with the yellow organism in cultures does not seem to influence the growth of the yellow organism. This is true so far as observed in surface growths on solid media.

THE ORGANISM

The organism being non-motile is referred to the genus Aplanobacter, and not agreeing in general with any previously described organism, the specific name *Agropyri* is suggested. It is therefore recorded as

Aplanobacter Agropyri sp. nov.

Morphology

Vegetative cells. The organism is a short rod with rounded ends. It is found singly or in pairs and infrequently may occur in chains of four. Organisms taken from four-day and fifteen-day sugar beet and potato cultures when stained with carbol-fuchsin are 0.4 to 0.6 by 0.6 to 1.1μ.

Those taken directly from the plant are usually a trifle smaller but in the main the organism taken from the plant and from various cultures seems to maintain a size practically within the limits given.

Endospores. No endospores have been observed.

Flagella. Many attempts have been made to demonstrate flagella from various cultures, using Moore's as well as Loeffler's methods, but without success.

Motility. The organism has been examined in agar hanging blocks and in beef broth hanging drops, but no distinct motion has been observed. Owing to the very characteristic viscid growth on various media it is perhaps quite certain that the organism is not motile.

Capsules. Capsules have been frequently demonstrated by Ribbert's and by Welch's methods. The organisms used for this purpose were grown on neutral nutrient agar and on potato and sugar beet slants.

Zoogloeae. Zoogloeae have not been seen in cultures of bouillon. On a few tubes of milk and litmus milk some very small floating zoogloeae-like bodies were found.

Involution forms. No involution forms have been observed.

Staining reactions. The organism stains readily with such stains as methylen blue, anilin-gentian-violet, and carbol-fuchsin. The latter stain produces beautiful results.

Gram's stain. Many efforts at staining were made with Gram's method but the results hardly warrant a conclusion. As a rule the stain was never completely lost nor was it ever retained in the original intensity. The anilin-gentian-violet and iodine solutions were used for two minutes and the preparations were then treated with absolute alcohol for three minutes. The mounts washed in alcohol lost a great deal of their intensity as compared with those not treated with alcohol and consequently the organism must be regarded as Gram-negative.

Acid-fast. The organism is not acid-fast.

Cultural characters

The first attempts at isolating the organism were uniformly unsuccessful. This was undoubtedly due to the viscidity of the slime, as has been noted in the isolation of other organisms which have the same characteristic. For the purpose of isolating the organism poured plates were made in various agars, but the one which was finally found to be best suited is neutral nutrient agar. Agar with a reaction of +15 did not seem to give good results as compared with the neutral agar. In order to make isolations it was found necessary to use a considerable quantity of the inoculum. Very thinly sown plates as a rule produced no colonies.

When sufficiently heavy sowings were made colonies began to appear in about eight days at temperatures of about 25°C. The same difficulty in the inoculation of liquid media was encountered. Unless a rather large number of bacteria were used the cultures failed altogether. This was particularly true of bouillon, milk and the various sugars used for fermentation studies. No perceptible odor could be detected in any of the culture media used.

After the organism has been cultivated in the laboratory for some time it is found that subcultures show a much more vigorous growth than when the organism is first isolated from the infected wheat-grass. Cultures made from these subcultures show very marked growth in all culture media that have so far been used.

Nutrient neutral agar colonies. When plantings were made in nutrient neutral agar plates, either directly from the host plant or from other culture media, liquid or solid, the colonies usually appeared in about eight days when incubated at a temperature of about 25°C. These colonies were globular and lenticular in form. The growth was very slow and as a rule surface colonies made very little progress and did not tend to spread very much from the centre. The surface of the colonies was generally slightly roughened and concentrically ringed. The growth was opaque and raised, with the edge more or less beaded or irregular. Under very moist conditions the colonies were generally much smoother both as to surface and edge. The color of these colonies after considerable growth became primuline yellow. The growth was very viscid. No liquefaction took place.

Nutrient neutral agar streaks. On slanted agar tubes a streak made with a platinum needle developed a somewhat slow growth. The streak widened toward the bottom of the slant but very little or no growth took place beneath the surface of the water of condensation. However, a primuline yellow precipitate in considerable amount was formed in the "V". The growth is so slow that under most conditions it rarely ever covers the surface of the slant, excepting near the bottom and above the water of condensation. At the upper part of the slant the growth is sometimes beaded; the streak is opaque, raised and glistening, being of a primuline yellow color. There seems to be no change in the color of the medium beneath the bacterial growth. The growth is very viscid and a platinum needle touched to it and then lifted, readily demonstrates this characteristic. Under proper conditions of moisture the growth usually has a glistening appearance. No liquefaction took place.

Nutrient neutral agar stab. In stab cultures practically no growth took place along the line of puncture beyond a distance of a few millimeters from the surface. The surface growth was slow at first but later (after

one month) covered the greater portion of the tube. This growth had a glistening appearance and was more or less contoured with the outer edges somewhat wrinkled. The growth was very viscid. There was no liquefaction of the agar.

Gelatin colonies. On neutral gelatin plates at about 20°C. the colonies appeared in eight to ten days as minute, globular or lenticular, whitish spots. Growth was extremely slow and the medium usually became very dry before there had been any considerable surface growth. Gelatin seems to be a decidedly poor medium for the organism. The color of the gelatin colonies was that denoted as mustard yellow, or perhaps a little lighter shade of yellow. There was no liquefaction of the gelatin during the period of observation. The growth in the gelatin plates was so poor that it cannot be said to have any particular characteristics.

Gelatin streaks. On slanted neutral gelatin at 20°C. streaks with a one millimeter loop developed very slowly, and never became much elevated as was the case in other media. After one month the growth was about three millimeters wide at the bottom and did not increase above the width of the original stroke at the top of the slant. The edges of the streak were more or less uneven; the growth was viscid; the surface was glistening; the color was mustard yellow or lighter in the thin portions of the streak.

Gelatin stab. In the gelatin stab at 20°C. the path of the needle became slightly beaded in the upper twenty-five millimeters of the medium in about ten days. There was no apparent growth at the bottom of the stab. The surface growth at the end of ten days was about four millimeters in width, the edges being slightly beaded and sometimes lobate. Under proper moisture conditions the growth was very much smoother than where the culture medium lacked sufficient water. The growth was viscid but scant. There was no liquefaction of the gelatin in seven weeks or in cultures held for four months.

Potato plugs. Potato plugs were inoculated with a platinum needle from agar colonies which were approximately two weeks old and kept at a temperature of about 25°C. At the end of about two days a light, mustard yellow, opaque streak developed along the path of the needle. There was a moderately good growth along the streak but it did not spread to any considerable extent at the upper or drier portion of the slant. At the lower portion of the slant near the surface of the water the growth was more spreading. At the end of ten days the growth at the upper end of the tube was approximately two millimeters in width, much raised and somewhat beaded along the edges, and of a primuline yellow color. The lower portion of the streak showed a more glistening surface or moist appearance and did not have the beaded character of the upper part of the streak. The surface of the upper part of the streak

was somewhat beaded or papillate. The growth tends to pile up and become elevated considerably above the surface of the slant. Cultures a month old become much darker, the color becoming very nearly raw sienna. The surface of the growth retained its papillate character. In some cases the surface of the growth had a shagreened appearance. The growth was very viscid, except in the upper portion of the slant where, owing to drying, it had a cheesy consistency. There was no perceptible odor and the substratum was not grayed. The potato is one of the best media for the cultivation of this organism. As a matter of fact, it was found to be much easier to isolate the organism by means of sterilized potato slices in petri dishes than by the use of agar plates. Thin flakes of the hardened bacterial ooze were separated from between the glumes and floral organs of infected spikelets. These were placed in droplets of sterilized, distilled water and the surface of the potato slices was streaked with a platinum needle which had been dipped in the water. By passing the needle repeatedly over the potato slices the sowing produced by the last strokes was very thin and from the colonies which developed in these thin streaks pure cultures were obtained.

Sugar beet. Plugs and slices of sugar beet were used in the same way as potato. The growth of the organism was practically the same although the color was sometimes a trifle lighter, being nearly mustard yellow. The edges of the streak as a rule were not so much beaded or papillate and the same was true of the surface. The growth was generally somewhat moist or glistening in appearance and always viscid. There was no perceptible odor.

Bouillon. Peptonized bouillon was made from carefully selected round-steak and was then made neutral according to Fuller's scale, it having been found that the organism grew best on neutral media, at least so far as our experiments have gone. Inoculations were made from a ten-days-old potato-tube culture, a small quantity of the viscid ooze being first put into a droplet of water and thoroughly distributed. Several one-millimeter loopfuls of bacteria were then transferred to the bouillon tubes and the cultures incubated at 25°C. The medium was slightly clouded after forty-eight hours. The clouding never increased to any great extent and at the end of ten days a light mustard-yellow precipitate began to form. At the end of twenty days the culture was practically cleared, with considerable light, mustard-yellow precipitate. There was no ring or pellicle formed. By twirling the culture between the hands the viscid slime at the bottom of the tube arose in stringy masses which did not tend to mix readily with the clear liquid. There was no perceptible odor.

Beef extract bouillon. This medium was not used.

Milk. Freshly drawn, throughly centrifuged milk, titrating +24 on Fuller's scale, was inoculated, without neutralizing, with bacteria in a

manner similar to that in which the bouillon tubes were inoculated, and the cultures kept at 25°C. There was no perceptible change in the milk for one month. The milk cultures remained the same as the milk in the check tubes with the exception of a primuline yellow precipitate. In only one or two tubes out of a dozen was there any appearance of zoogloeae-like bodies or a surface ring. At the end of three months there was a primuline yellow precipitate about three millimeters deep and a surface ring of the same color approximately one-half centimeter wide. In four months the ring had widened to two centimeters with no increase in quantity of precipitate. There was a change in the consistency of the milk due to evaporation. No odor could be detected. The color of the milk at the end of three months remained the same as in the check namely, a very light, ivory yellow. Caesin was not precipitated. Titration showed the cultures to be +28 on Fuller's scale, showing increased acidity. At the end of four months there was no change in the color of the milk, but some casein was precipitated.

Litmus milk. Milk from the same stock was used in preparing the litmus milk tubes. Transfers were made in the same way. The color of the litmus milk as made up was very nearly wistaria blue. At the end of about one month there was a viscid, primuline yellow precipitate, approximately three millimeters deep. In two tubes there was an imperfect, mustard yellow ring and the appearance of small zoogloeae-like bodies. A very slight reduction of the litmus had taken place. In tubes three months old some reduction took place in the color, which became a very light campanula-blue, but at the end of ten days thereafter most of the original color returned. It was also found that the original color could be partially restored by a vigorous twirling or shaking of the tubes. In four months the ring had slightly widened and the precipitate was somewhat increased. The litmus was practically all reduced, only a half centimeter ring at the upper end of the tube remained, the color being pale Hortense violet. The portion below the colored ring became cartridge buff and of thick consistency due to evaporation. The growth in the litmus milk tubes was of the same viscid nature but there was no change in the consistency of the medium excepting that due to some precipitation of casein. There was no perceptible odor. The titration showed that the amount of acid liberated was the same as in the milk tubes as shown above. Milk is an excellent medium for the culture of this organism. Vigorous growth was obtained on potato slants when inoculated from milk tubes six months old.

Physical and biochemical characters

Fermentation tubes. A basal solution was made up by adding 1 per cent Witte's peptone to filtered tap water. Four solutions were made from this,

each containing, respectively, 2 per cent of one of the following carbon compounds: glycerine, saccharose, dextrose and lactose. Five fermentation tubes were filled with each of these solutions and sterilized by heating for twenty-five minutes on three successive days. Three tubes of each set were inoculated and two were left as checks. The tubes were inoculated in the same way as has been described for other fluid media. After about three days the open end of the tubes in all of the solutions was slightly clouded. This cloudiness increased up to about fifteen days in most of the tubes. The line of demarcation between the clear liquid in the closed arm and in the open arm was not very clearly marked. However, there was no apparent cloudiness beyond the narrow neck of the tubes. In each case there was a slimy precipitate at the bottom of the open arm, somewhat resembling the precipitate formed in the bouillon tubes. The fact that no growth occurred in the closed arm of the fermentation tubes tends to point strongly toward the aerobic nature of the organism. This is further shown by the fact that the organism did not tend to grow at the bottom of the agar or gelatin stabs. The cultures were tested for acidity after they had grown for eighteen days. Another lot was tested for acidity at the end of four months. At the end of eighteen days the tubes titrated (Fuller's scale) as follows: saccharose +5, dextrose +8, lactose +4, glycerine +5. The check tubes showed a reaction of +0.5. At the end of four months the saccharose medium titrated +9, dextrose +11, lactose +8. The glycerine medium in fermentation tubes was not tested at the end of four months. No gas was formed in the closed arm of any of the fermentation tubes. There was no perceptible odor.

Nitrates. Six tubes, each containing ten cubic centimeters of peptonized beef broth, to which had been added 1 per cent nitrate of potash, were used. Two tubes served as a check and four were inoculated in the same manner as previously described for other liquid culture media. At the end of five days the tubes were considerably clouded and were then tested for nitrates in the following manner: To each culture one cubic centimeter of boiled starch water and one cubic centimeter of potassium iodide solution (1–200) were added. Upon adding a few drops of strong sulphuric acid water (2–1) the cultures immediately became blue-black, showing that free iodine had been liberated. The starch solution and the potassium iodide water had been freshly prepared and were carefully tested before being used by making use of the checks as well as by testing the reagents independently.

Diastatic action. The test for diastatic action was made on scrapings from potato slants. Potato cultures about three months old were taken and the culture covering the surface carefully removed. Scrapings were

then taken from the surface, which had not been grayed, and crushed in a porcelain mortar with a few cubic centimeters of water. Upon adding a weak solution of iodine in potassium iodide a very beautiful purplish color appeared, showing that diastatic action had taken place. Check tubes of the same age were tested in a similar manner when a blue color resulted.

Thermal death point. The thermal death point has not been carefully determined, but is probably not far from 50°C.

Optimum temperature. The optimum temperature for this organism appears to lie between 25° and 28°C.

Maximum temperature. The maximum temperature has not been carefully determined.

Sensitiveness to drying. No direct tests were made of the organism dried on carefully sterilized cover slips, but material taken from dried glumes which had been in the laboratory eleven months showed vigorous growth when inoculated into the proper media. Under this condition it would seem that the organism retains its vitality for a considerable length of time, perhaps a year or more.

Group number

The group number, according to the descriptive chart of the Society of American Bacteriologists, is 212.2223522.

Natural infection

As indicated in the first paragraphs, little or nothing is known concerning natural infection. It may be stated, however, that work along the line of determining how natural infection occurs is under way and these studies will be reported later.

Pure cultures of the organism, as well as material which has been collected in the Salt Lake and Utah Valleys, will be sent upon request in so far as the supply will permit.

DEPARTMENT OF AGRICULTURAL INVESTIGATIONS
AMERICAN SMELTING AND REFINING COMPANY
SALT LAKE CITY, UTAH

EXPLANATION OF PLATE IX

FIG. 1. Inflorescence of *Agropyron Smithii* showing natural infection produced by *Aplanobacter Agropyri*. One and one-third times natural size. Specimen collected near Murray, Salt Lake County, Utah, June 29, 1915. Original.

FIG. 2. Inflorescence of *Agropyron Smithii* showing natural infection produced by *Aplanobacter Agropyri*. One and one-third times natural size. Specimens collected near Murray, Salt Lake County, Utah, August 23, 1915. Note the darker color of the bacterial ooze due to weathering. Original.

O'GARA: APLANOBACTER AGROPYRI

Explanation of Plate X

Fig. 1. Litmus milk culture of *Aplanobacter Agropyri* incubated at a temperature of 25°C. Painted when four months old. Original.

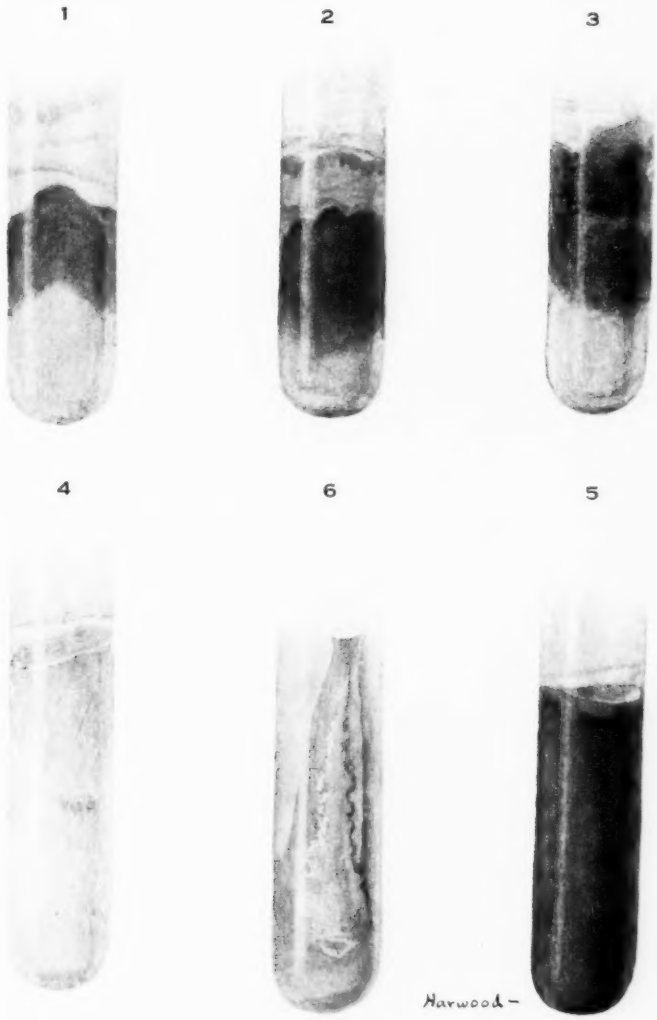
Fig. 2. Litmus milk culture of *Aplanobacter Agropyri* incubated at a temperature of 25°C. Painted when three months old. Original.

Fig. 3. Litmus milk culture of *Aplanobacter Agropyri* incubated at a temperature of 25°C. Painted when three and one-half months old. Original.

Fig. 4. Milk culture of *Aplanobacter Agropyri* incubated at a temperature of 25°C. Painted when four months old. Original.

Fig. 5. Check tube of litmus milk. Original.

Fig. 6. Potato slant culture of *Aplanobacter Agropyri* incubated at a temperature of 20°C. Painted when twelve days old. Original.



O'GARA: APLANOBACTER AGROPYRI

Explanation of Plate XI

Fig. 1. Photomicrograph of *Aplanobacter Agropyri* from slide No. 111915; organisms from four-days-old sugar beet culture No. 111515, stained three minutes with carbol-fuchsin. Photograph made with B. & L. 1.9 mm. objective, Zeiss No. 2 projection ocular. × 1000. Original.

Fig. 2. *Bacillus subtilis* magnified × 1000; for comparison with figure 1. Original.

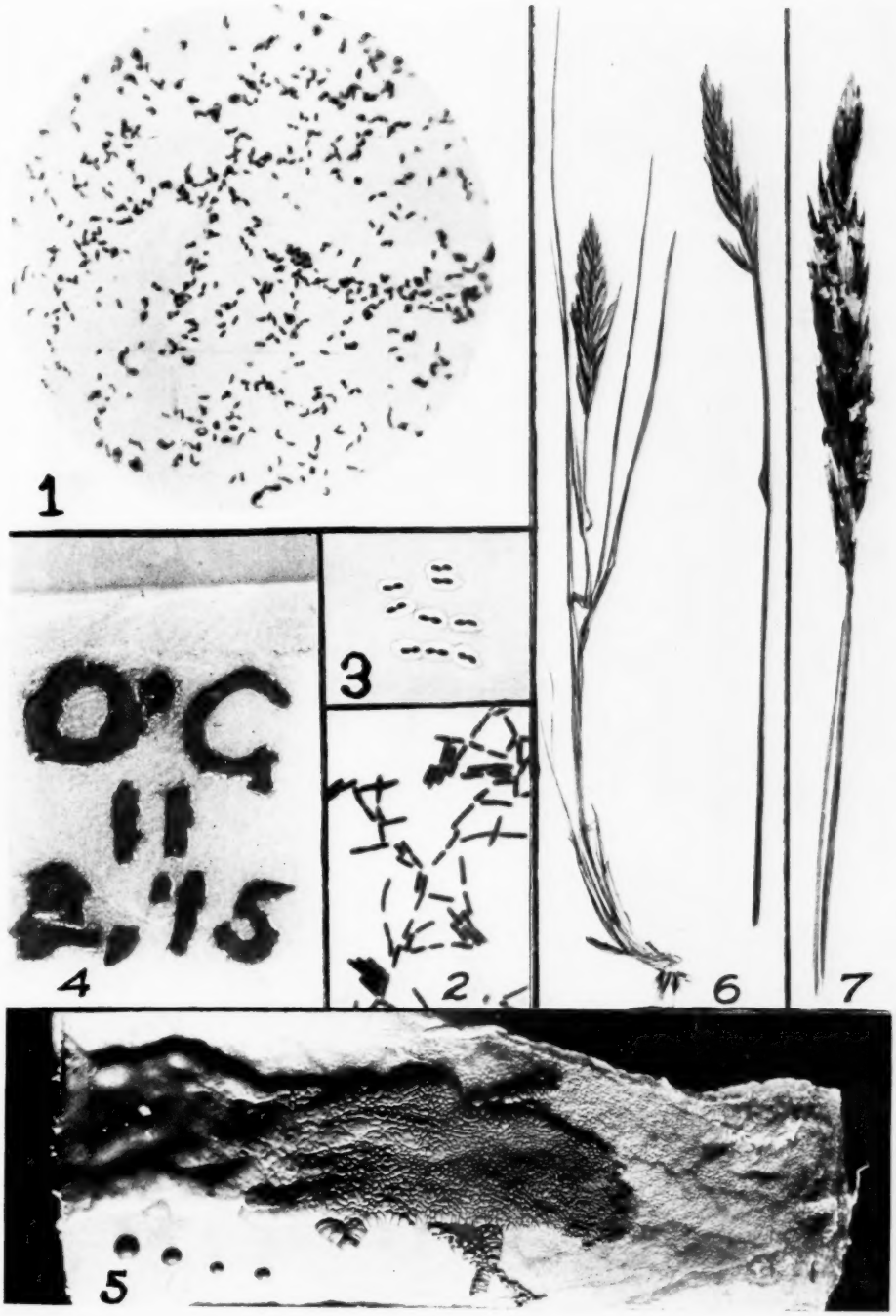
Fig. 3. *Aplanobacter Agropyri* showing capsules. Organism stained by Ribbert's method; from ten-days-old potato culture. (Original wash drawing.)

Fig. 4. Culture of *Aplanobacter Agropyri* on sugar beet slice No. 11215; culture ten days old when photograph was made. Natural size, showing raised character of bacterial growth. A platinum loop very nearly the width of the streaks was used in inoculating. This shows the non-spreading character of the organism. Original.

Fig. 5. Photograph of ten-days-old potato slant culture of *Aplanobacter Agropyri* showing the upper end of the slant. × 5. Note the shagreened appearance of the surface growth. Original.

Fig. 6. Specimens of *Agropyron Smithii* showing the peculiar bends in the stems produced by *Aplanobacter Agropyri*. Specimens collected near Murray, Salt Lake County, Utah, August 23, 1915. One-half natural size. Original.

Fig. 7. Photograph of inflorescence of *Agropyron Smithii* showing the bacterial ooze collected in droplets on the glumes. Specimen collected near Murray, Salt Lake County, Utah, August 23, 1915. Nearly natural size. Original.



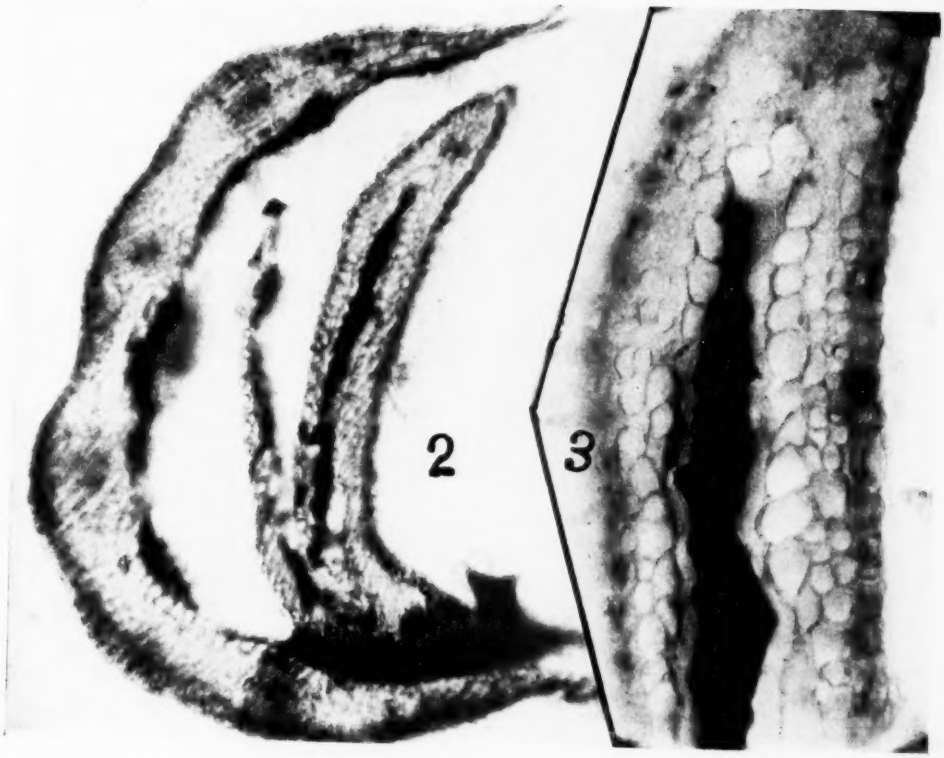
O'Gara: Aplanobacter Agropyri

Explanation of Plate XII

Fig. 1. Cross-section of upper one-third of diseased inner glume of *Agropyron Smithii* from material collected July 6, 1915, cut and mounted unstained September 1, 1915; photograph made with B. & L. 16 mm. objective, no. 2 Zeiss projection ocular, November 14, 1915. × 87. The amorphous masses between the cross-sections of the parts of the glume are composed of yellow, bacterial slime which has become hardened. In cutting the section the tissues were separated from the bacterial masses. Original.

Fig. 2. Cross-section of lower one-third of spikelet of *Agropyron Smithii*, from material collected July 6, 1915, cut and mounted without stain August 23, 1915; photograph made with B. & L. 16 mm. objective, Zeiss no. 2 projection ocular. November 14, 1915. × 100. The amorphous masses between the cross sections of the glumes are composed of hardened, yellow, bacterial slime. Original.

Fig. 3. Cross-section of inner glume of *Agropyron Smithii*, the part being selected from the lower one-third of glume as shown in figure 2; photograph made with 4 mm. B. & L. objective, Zeiss no. 2 projection ocular, November 11, 1915. × 331. The black amorphous mass consists of hardened, yellow, bacterial slime. It is readily seen that the bacteria have not entered the cells or the intercellular structure of the glume. Original.



O'GARA: APLANOBACTER AGROPYRI

Explanation of Plate XIII

Fig. 1. Cross-section of upper one-third of normal spikelet of *Agropyron Smithii* showing the inner and outer glumes together with the three anthers in cross-section. The pollen grains can readily be made out. From material collected near Murray, Salt Lake County, Utah, July 6, 1915, cut and mounted without stain August 23, 1915. Photograph made November 14, 1915, with 16 mm. B. & L. objective, Zeiss no. 2 projection ocular. × 78. Original.

Fig. 2. Median cross-section of spikelet of *Agropyron Smithii*, cut and mounted August 14, 1915, from material collected July 6, 1915, near Murray, Salt Lake County, Utah. Photograph made November 14, 1915, with 16 mm. B. & L. objective, Zeiss no. 2 projection ocular. ×78. The amorphous masses between the sections of the inner and outer glumes are composed of hardened, yellow, bacterial slime. Original.

O'GARA: APLANOBACTER AGROPYRI

THE OCCURRENCE OF BAMBOO SMUT IN AMERICA

FLORA W. PATTERSON AND VERA K. CHARLES

WITH ONE FIGURE IN THE TEXT

Among the plants of special interest and economic importance which have been introduced from abroad through the Office of Foreign Seed and Plant Introduction are the bamboos. The popular but erroneous conception regarding these plants is that they are largely tropical, mainly adapted for ornamental purposes, but not of particular utilitarian value. Many Japanese bamboo plants had been growing in the United States prior to the work of introduction by the Department, but the object of the latter was to secure and to establish the timber species and to interest a large class of cultivators in the regions suitable for the growing of bamboos. The Department has imported several species of bamboo, mainly members of the genus Phyllostachys, but the two of special interest in this paper and of economic importance as timber species are *P. henonis* Mitford (*P. puberula* Munro) and *P. quilioi* Rivière (*P. bambusoides* Sieb. and Zucc.). The introduction of any new plant is always a question of serious concern, not only because of the expense which the government agricultural explorer must incur, the difficulties and hardships to which he may be subjected, but also because of the possibility of the introduction of new plant diseases which may not only kill the new introduction but attack also the plants indigenous to this country or those already successfully established.

In March, 1910, the Office of Foreign Seed and Plant Introduction ordered consignments of *Phyllostachys henonis* to be sent from its field station located at Chico, California, to Brooksville, Florida, and to Avery Island, Louisiana. A diseased condition of the plants remaining at Chico was observed shortly after the shipments had been made and an order was immediately sent to the points of destination directing the plants not to be unloaded until further notice. At the same time specimens from Chico were forwarded to the Office of Pathological Collections and Inspection Work for the identification of a probable pathogenic organism. The trouble was promptly diagnosed as a fungous disease, caused by a species of Ustilago. Its serious nature was immediately recognized and in accordance with the advice given by this office, an order was issued by the Office of Foreign Seed and Plant Introduction to inspect carefully

FIG. 1. Diseased and normal stalks of *Phyllostachys henonis* affected by the bamboo smut, *Ustilago shiraiana* Henn.

all plants and to treat or burn any showing the slightest evidence of disease.

For many years it has been the regular policy of the Department of Agriculture to inspect all foreign importations received at Washington, but these plants had been imported from Nagasaki, Japan, through the port of San Francisco in February, 1909.

DISCUSSION OF THE FUNGUS

In 1900,[1] Dr. Paul Hennings described a smut on a wild Japanese bamboo, *Sasa ramosa*, which he named *Ustilago shiraiana*. In 1905,[2] Dr. Shorato Hori published an article on smut of the large cultivated bamboo in which he states that he had received a specimen of smutted *Phyllostachys puberula* from the province of Mino in 1894. This specimen had been retained in the herbarium of the station at Tokyo under the unpublished name of *Cintractia bambusae* Miyabe and Hori. Later Dr. Hori had an opportunity to examine additional diseased material not only of *P. puberula* (*P. henonis*) but also of *P. bambusoides* (*P. quilioi*), and also had an opportunity to observe the disease in several provinces of Japan. A careful study was made of the microscopic characters of the fungus and exact measurements were obtained of the spores on the different hosts. While this study caused Dr. Hori to make certain changes in the description of *U. shiraiana* Henn., he concluded that these smut fungi are identical and designated his species as *U. shiraiana* Hennings.

The fungus appears on the internodes and young growing parts of the branches as a deep brown, sooty mass. If examined microscopically, this mass is shown to consist of numerous spherical, subglobose or elliptical spores, light olivaceous to brown in color, with rather thin, smooth epispore and granular contents.

The following is the description of the fungus as emended by Dr. Hori:[3]

> Produced on the growing points and internodes of the young branches causing often deformation or distortion; spore-masses at first covered by the leaf-sheath and bracts, pulverulent, deep brown; spores spherical, sometimes subglobose or elliptical, the rounded ones 6 to 10 μ in diameter, and the elongated ones 5.5 to 10 by 6 to 12 μ in size.
>
> Epispore light olivaceous, smooth, contents finely granular with some oil globules; promycelium cylindrical or long fusiform, pedicellated, 1 to 2 septate, evanescent; sporidia terminal and lateral, long fusiform or elliptical, develop into the new promycelium.

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[1] Hennings, P. Fungi japonici, I. Engler's Bot. Jahrbüch. **28:** 260. 1900.

[2] Hori, S. Smut on cultivated large bamboo (Phyllostachys). Bul. Imp. Cent. Agr. Exp. Sta. Japan, **1:** 73. 1905.

[3] Hori, S. Bul. Imp. Cent. Agr. Exp. Sta. Japan, **1:** 86. 1905.

SYMPTOMS OF THE DISEASE

According to Dr. Hori's investigations and observations of the writers the disease always occurs on the young and growing points of branches. When the young, short branches, still covered by the leaf-sheaths and bracts, are attacked they appear somewhat swollen but show no external discoloration. The growth of such diseased branches is arrested and finally, as the external covering of the buds falls away, the sooty portions are exposed. In cases in which most of the young branches are diseased, the winter buds or undeveloped spring buds begin to develop, and at a certain stage of the disease a hexenbesen or witches' broom formation is often apparent.

DISSEMINATION OF THE FUNGUS

Dr. Hori states that the wind is the principal factor in the dissemination of the disease and observes that the branches of bamboo growing on the outside of a grove are much more smutted than those farther in the forest. The important question which confronts the Department of Agriculture, in relation to the importation of bamboo or the distribution of bamboos already established in the United States, is whether the fungus may remain dormant in the rhizomes or stems for an indefinite period, making its appearance when conditions are favorable. The observation and experience of this office indicate that the fungus may remain dormant or at least may not produce the characteristic smutted appearance for some time. This inference is drawn from the fact that plants of *P. henonis* imported from Nagasaki, Japan, in February, 1909, did not show conspicuous spore formation until over a year later. *P. quilioi* was received from the same locality at the same time but no specimens were sent for identification until 1914. Of course, it is possible that the disease may have occurred prior to 1914, but if so, it was not sufficiently conspicuous to attract the attention of the plant introducers or propagators.

GEOGRAPHIC DISTRIBUTION

According to Dr. Hori,[4] smut has been found on several kinds of bamboo, both wild and cultivated, throughout the Empire of Japan. He states that it is known to occur on the four following species of bamboo: *Phyllostachys bambusoides* Sieb. & Zucc., *P. puberula* Munro, *Sasa ramosa* Makino and Shibata, and *Arundinaria simoni* Riv. var. *chino* Makino and Shibata.

[4] Hori, S. Bul. Imp. Cent. Agr. Exp. Sta. Japan, **1**: 78. 1905.

In conversation it was learned from Mr. Frank N. Meyer, Agricultural Explorer for the Department of Agriculture, that he has observed the disease in China, especially in the province of Chekiang.

In America the disease has been observed on *P. henonis* and *P. quilioi* as already stated in this paper.

SEVERITY OF THE DISEASE

In Japan this disease is extremely serious and of greatest economic importance to the bamboo grower, as it may lead to the death of the entire forest.

In view of the seriousness of the disease the Department would urgently recommend that all bamboo growers watch their plants for any evidence of smut. When we consider that the monetary loss of small grains from smuts in the United States can be estimated at from twenty-eight to thirty-five millions of dollars annually, we appreciate the great importance of eradicating this disease before it has become established in our bamboo plantations. With this object in view steps have been taken to control the situation.[5] The presence of the fungus not being conspicuous in the early stages, it is well to scrutinize the young growth closely, opening the glumes and running the fingers along the internodes to discover whether the black, powdery spores of the smut are present. As a witches' broom formation is sometimes associated with this disease, the grower should watch for any such appearance and hold the plants so affected under careful observation.

CONTROL

Fungi of this class are exceedingly difficult to control, the method of treatment being prophylactic rather than palliative or curative. In the control of smuts on cereals, the seeds are frequently subjected to fungicidal treatment before planting and thus the chances of seed infection are obviated or in a large degree lessened. In bamboo, because of the perennial habit of the plants and the different method of propagation, this treatment is not practicable. Theoretically, breeding and selection of resistant varieties would appear to be the most promising method of controlling the disease. Burning all diseased plants is the only sure means of eradicating this fungus. Spraying with bordeaux mixture when the

[5] Realizing the potential seriousness of the smut disease of bamboo the Department prepared a circular letter of warning, containing a description and illustrations of the disease, and distributed copies to all those interested in bamboo culture in the United States. In this letter growers were requested to send any suspicious material to the Department for mycological identification and pathological advice.

spring buds begin to develop has been suggested as probably beneficial and may lessen the danger of reinfection but it cannot be regarded as a positive means of control.

Although our opportunity of studying the disease has been extremely limited and confined to laboratory investigations, we are inclined to believe that the mycelium may persist for a long time in the older stems and give rise to successive infections. This point, however, can be determined only by extensive field observations and microscopic studies.

OFFICE OF PATHOLOGICAL COLLECTIONS
BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C.

SPORE VARIATION IN NEOPECKIA COULTERI

J. S. Boyce

While examining some collections of *Neopeckia coulteri* (Pk.) Sacc., the writer found, in material collected by E. P. Meinecke on *Pinus monticola* near Grassy Lake, Shasta County, California, at an elevation of 7000 to 8000 feet on September 26, 1914, that certain of the spores had become two- and sometimes three-septate by the formation of a secondary septum in either one or both of the original spore halves.

In all, sixteen collections of *Neopeckia coulteri*, made by Meinecke and the writer in the Sierra Nevada and Siskiyou Mountains of California at elevations varying from 5800 to 11,500 feet, have been examined. Absolute identifications have been possible of five specimens on *Pinus contorta* (*murrayana*), three on *P. monticola*, two on *P. albicaulis* and one on *P. ponderosa*. This last-named host is new for the species. This latter collection was made by the writer near Hobart Mills, Sierra County, California, on September 28, 1914 at an elevation of 6300 feet. Only a few small saplings were found attacked by the fungus. In the remaining five collections, two on *Pinus jeffreyi*, two on *Pinus lambertiana* and one on *Pinus monticola*, no ascospores were found so it is assumed that the fungus is *Neopeckia coulteri;* a logical assumption, since our present knowledge is that the only fungus occurring on coniferous species in this country within the range of *Neopeckia coulteri* and closely resembling it is *Herpotrichia nigra* (Pk.) Sacc., never reported in North America on any species of Pinus while *Neopeckia coulteri* has never been reported on any host other than Pinus. However, material on *Pinus montana* from the Bavarian Alps (in E. P. Meinecke's herbarium, obtained through the courtesy of Dr. von Tubeuf, Munich), upon examination, was found to be *Herpotrichia nigra*.

In all the collections of Neopeckia, with the one exception, the spores were characteristically and invariably uniseptate. Nor can the writer find any reference in the literature on the subject to a variation in this respect. Sturgis[1] describes the spores as, "strictly uniseriate, 2-celled, and becoming very dark brown as they mature," and again (p. 157), "Spores obliquely uniseriate in the asci, blunt elliptical, at first pale brownish, later dark brown, 1-septate, constricted at the septum, 20-29

[1] Sturgis, W. C. Herpotrichia and Neopeckia on conifers. Phytopath. **3**: 156. 1913.

x 9.5–10.2 μ." Engler and Prantl[2] characterize the spores of the genus as "Sporen 2-zellig, braun," while Ellis and Everhart[3] write "Sporidia uniseriate, oblong elliptical, slightly narrowed at the ends, uniseptate and constricted, brown, 20–30 x 8–10 μ."

In all the spores examined from the first-mentioned material on *Pinus monticola*, one spore-half usually appears slightly narrower than the other. In those spores with one additional septum, the primary septum is very plain and is accompanied by the characteristic constriction of the spore. The additional septum divides the narrower of the original spore-halves transversely into two equal secondary cells, but there is no constriction or only a very slight one; in some instances, the secondary septum is rather faint. This secondary septum is invariably found in the narrower of the spore-halves. In those spores in which both spore-halves are divided by additional septa into two secondary cells each, the primary septum is plain, with the usual constriction, while the secondary septa vary in distinctness; the constriction is lacking or very slight. The three types of spores do not have any definite position in the ascus, as one-, two- and three-septate spores or combinations of these were found in various parts of the same ascus.

A count of 500 spores gave 433 (86.6%) uniseptate, 58 (11.6%) biseptate and 9 (1.8%) triseptate. The results of the spore measurements[4] are as follows:

Uniseptate spores—(63) 7–11 μ x 23–27 μ (8–10 x 22–25).

Biseptate spores —(30) 7–10 μ x 22–27 μ (8– 9 x 25–27).

Triseptate spores —(6) 8–10 μ x 23–27 μ (8– 9 x 23–25).

As can be seen, the difference in size between the three types of spores is trifling. With the increase in the number of septa there is no increase in width of the spores at all. There is no increase in length except, seemingly in the case of biseptate spores, due, no doubt, to the unavoidable variations that always enter into measurements of this kind. That there is no real increase in length is shown by measurements of individual, original spore-halves without and with a secondary septum. The measurements are:

Spore-halves without secondary septum—(25) 7–9 x 12–14 (8–9 x 12–13).

[2] Engler, A. und Prantl, K. Die Natürlichen Pflanzenfamilien, I Teil, 1 Abt., p. 396.

[3] Ellis, J. B. and Everhart, B M. The North American Pyrenomycetes, p. 147.

[4] Meinecke, E. P. Spore measurements. Science n. s., **42**: 430. 1915.

In the measurements of the uniseptate spores for example, (63) is the numerical basis, 7–11 x 23–27μ are the extremes of width and length, while (8–10 x 22–25μ) are the most frequent values of width and length.

Spore-halves with secondary septum—(25) 7–9 x 12–14 (8–9 x 12–13).

A hanging drop culture of the spores suspended in tap water was made on April 20, 1915. By May 5, 1915 the swollen spores had germinated vigorously. Slits, or rarely, irregular tears appeared in the exosporium of the uniseptate spores and through these openings the hyalin germ-tubes grew out. These narrow and short slits, revealing the hyalin spore-contents, stood out clearly against the dark brown exosporium. In each spore-cell from one to three slits were formed, each one of which might be occupied by a germ-tube, though as a rule there were more slits than germ-tubes.

In accordance with their numerical relationship to the uniseptate spores, only five biseptate spores were found in the culture. One of these had not germinated, one had sent out a germ-tube from a secondary cell, while in the other three a germ-tube appeared from each cell. The splitting of the exosporium was again in evidence. This faculty of germination characterizes the formation of secondary cells as a normal, not a pathological, process. None of the rare triseptate spores had germinated.

In all of the material examined, two triseptate spores were found with pronounced constrictions at each of the three septa, giving the spores, except for the dark brown color and slightly larger size, the appearance of those of *Herpotrichia nigra*. On the other side, Meinecke's collections contain a *Herpotrichia* sp., found on *Primula* sp., with the normal biseriate triseptate spores of *Herpotrichia nigra* but of very large size. Their dark brown color, however, remind one distinctly of *Neopeckia coulteri*. Weir[5] describes a new species of Herpotrichia (*Herpotrichia quinqueseptata*) with 5-septate spores occurring on *Picea engelmanni*.

The triseptate Neopeckia spores described above and the Herpotrichia spores from Primula represent intermediate forms between *Neopeckia coulteri* and *Herpotrichia nigra* suggesting a very close relationship of the two fungi, which macroscopically cannot be distinguished from each other.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
BUREAU OF PLANT INDUSTRY
SAN FRANCISCO, CALIFORNIA

[5] Weir, James, R. A new leaf and twig disease of Picea engelmanni. Jour. Agr. Research **4**: 251–253. 1915.

KEITHIA THUJINA, THE CAUSE OF A SERIOUS LEAF DISEASE OF THE WESTERN RED CEDAR

JAMES R. WEIR

WITH TWO FIGURES IN THE TEXT

Observations in the lake region of northern Idaho during the field seasons from 1912 to 1915 show that *Keithia thujina* Durand[1] is the cause of a serious leaf disease of the western red cedar, *Thuja plicata* Don. This is important since the fungus has not been heretofore reported on this valuable timber tree, moreover it is the only fungus of economic importance so far found attacking the leaves of this species (fig. 1).[2]

Since the fungus is likely to become serious in forest nurseries and of considerable importance in the forest, its chief characteristics should be reviewed. The apothecia are embedded in the tissues of the scale-like leaves of the host and are exposed on maturity by the rupture of the epidermis as a flap or scale (fig. 2, *a*). The cushion-like apothecia depressed or elevated according to the humidity of the air are circular, elliptical, curved or irregular in outline and may occur three or more on a leaf (fig. 2, *b*). At first they are a rich olive-brown but become almost black with exposure. The ascus bears two highly characteristic spores which are at first hyaline, elliptical or pyriform in shape (fig. 2, *c*) but on reaching maturity become olive-brown and more circular in outline (fig. 2, *d*). The spores are further characterized by a pitted surface and by being divided into two very unequal cells by a transverse wall at the distal end (figs. 2, *d* and *e*). The paraphyses are septate, branched or single and broadly thickened at the ends (fig. 2, *d*).

Durand's surmise[3] that *Keithia thujina* "under favorable conditions or in certain seasons might become serious" is well founded. The leaves of trees of all age classes are attacked, the severity of the attack depending upon the humidity of the site. The lower branches of young trees from twenty to fifty years of age, when growing in dense stands on low ground, often appear at a distance as if scorched by fire. In October and No-

[1] Trans. Wis. Acad. Sci. Arts Let. **16**: 759. 1909. Mycologia **5**: 9–10. January, 1913.

[2] The writer is indebted to Dr. F. J. Seaver for the determination of the fungus. Material was also compared with collections made by Dr. J. J. Davis on *Thuja occidentalis* at Hickory, Wisconsin. (Fungi Columbiani 4030.)

[3] Mycologia **5**: 10. January, 1913.

vember the young infected leaf-twigs fall leaving the branches quite bare. On leaves remaining attached to older twigs, the presence of the fungus is readily determined by the fact that the apothecia fall out leaving a pit that almost perforates the leaf (fig. 2, *b*). These leaves turn an ashy gray contrasting with the reddish brown leaves which fall earlier in the year. Seedlings under four years of age are killed outright in a single season.

FIG. 1. Branch of *Thuja plicata* infected with *Keithia thujina;* natural size.

A plot of fifty square feet of heavy reproduction in open forest in the Kaniksu National Forest (Priest River Valley) containing four hundred and thirteen seedlings showed by actual count four hundred seedlings killed by this fungus, or about 97 per cent of the entire stand. Infections equally severe occur in many parts of the forest.

Keithia thujina is primarily a fungus of seedlings and young trees. The foliage of the upper crown of large forest trees may be very generally infected but never to the same extent as the leaves on branches near the ground. The fact that seedlings are usually severely infected indicates that snow may be a factor in promoting its growth. This is particularly noticeable where seedlings remain covered with snow until late in

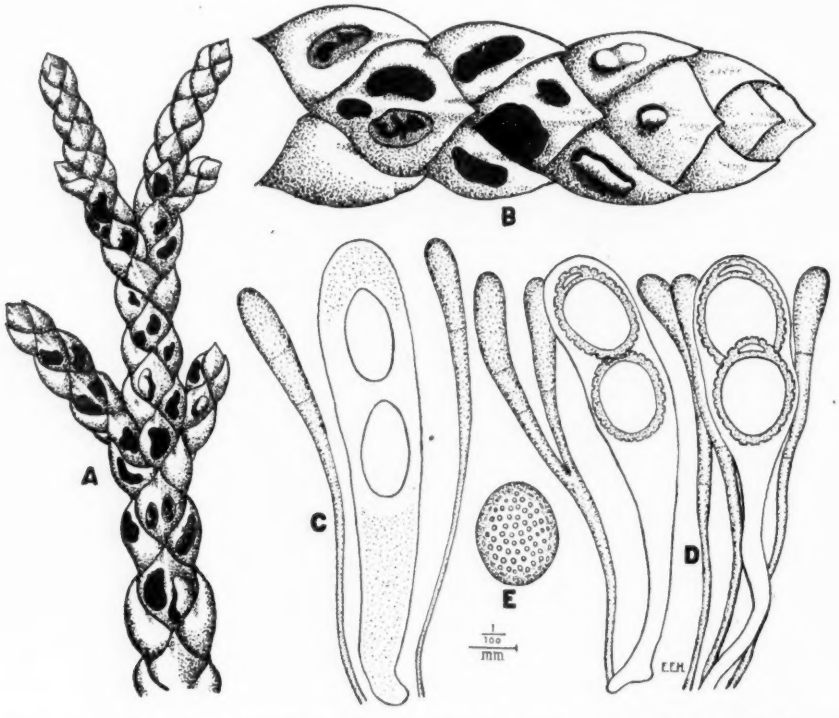

FIG. 2. *A*, Branch of *Thuja plicata* infected with *Keithia thujina* showing forms of apothecia with epidermal scale. *B*, Leaves of *Thuja plicata* infected with *Keithia thujina* showing apothecia much enlarged with epidermal scale falling away, also pits in the leaf after the disappearance of the apothecia. *C*, Immature ascus and spores of *Keithia thujina*. *D*, Mature asci and spores of *Keithia thujina* showing the small cell at distal end of spore. *E*, Spore of *Keithia thujina* showing surface markings.

the spring. The branches of young trees growing in deep ravines which are covered with snow for a long period of time are generally more severely attacked than those branches higher on the trunk. The fungus is at all times most abundant in regions of great atmospheric humidity.

Sporulation begins about the last part of June. By the middle of October the asci have discharged the most of their spores while the apo-

thecia are still attached to the leaves. Spores may be found in limited quantity in the apothecia after they have fallen from or together with the leaves. The hygroscopic nature of the substance of the apothecium which causes it to swell out like a cushion during wet weather is a factor in spore liberation. This also initiates the formation of the fissure around the apothecium resulting in its fall from the leaf.

Keithia thujina is widely distributed throughout the range of its host, having been found from southern British Columbia to central Oregon and eastward to the Bitter Root Mountains in Montana.

The fact that the spores of *Keithia thujina* are principally disseminated during the autumn months while the infected leaves are still attached led to the following preliminary experiment. On August 3, 1914, six seedlings ranging in height from four to six inches were taken up in a part of the Priest River region where the fungus has not yet appeared and transplanted into the midst of a heavy reproduction of cedar (Thuja) of about the same size and which was severely infected with the fungus. The six seedlings remained thrifty after transplanting. From the time of transplanting and extending into October, three of the seedlings were heavily treated with the stronger soap-bordeaux solution at intervals of ten days or oftener during rainy weather. When examined on April 5, 1915, one of the sprayed seedlings showed four infections on as many leaves. The other two were entirely free from the disease. The three seedlings which were not treated were as severely infected as those of the original stand. This result, though based on a single experiment, indicates that the disease may possibly be controlled in nurseries, if at any time it is found necessary, by using the above well-known remedy.

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TWO INTERESTING DISEASES OF GREENHOUSE TOMATOES

MEL T. COOK AND C. A. SCHWARZE

WITH ONE FIGURE IN THE TEXT

During the spring of 1915 two very interesting fungous diseases of tomatoes appeared in the greenhouses of the New Jersey Agricultural Experiment Station. One fungus occurred as a leaf parasite, while the other confined its activities to the fruits.

The lesions of the leaf parasite first appeared as small, brown, circular spots which gradually became larger and grayish brown in color. These spots were marked with delicate, black, more or less irregular concentric circles and were somewhat similar in appearance to the spots of the early blight caused by *Macrosporium Solani* E. & M. An examination of the spot with the hand lens revealed many small, black pustules. After a few hours in the moist chamber, great numbers of whitish spores were exuded in strings from these pustules.

The fungus corresponds with *Ascochyta Lycopersici* Brun., which is recorded in Saccardo's *Sylloge Fungorum* (**10**: 304) as occurring on the leaves of weak tomato plants in Italy and France, except that our organism occurs on both old and new leaves of strong plants and also on vigorous young plants. The pycnidia are usually globose, sometimes ellipsoid or irregular. The spores are hyaline, one-septate, slightly constricted at the septum and 7.5 to 9 by 2.5 μ.

In culture the organism produced an abundant growth of mycelium on several different media and also pycnidia without spores. The mycelium is whitish becoming black with age. Puncture inoculations, made with the mycelium from cultures, on the leaves and green fruits of healthy, vigorous plants produced typical spots in a few days.

The disease cannot be considered of very great importance. It was most severe on the magnus and the yellow and red plum varieties.

The fruit rot lesion started at the blossom-end of ripe and half ripe fruit, gradually spreading and exhibiting symptoms practically the same as those usually described for the blossom-end- or point-rot. The surface of the rotten area very soon became covered with a dense grayish brown powdery mass which proved to be a species of Botrytis.

The fungus was isolated in cultures and made luxuriant growths on tomato plugs, potato agar and Cook's No. II, producing large, black

sclerotia. The spores are egg-shaped, smoke colored and 7.5 to 10 by 6 to 7 μ.

The disease was most common on fruits with roughened blossom-ends. Under the quiet conditions of the greenhouse, the dead blossoms frequently cling to the blossom-ends of the fruits. Under the moist conditions of the greenhouse, these dead blossoms present especially favorable conditions for the growth of the fungus which penetrates the fr it through the roughened surface and causes the typical blossom-end-rot. Examination of these dead blossoms found clinging to the fruits and also on the ground, showed them to be always filled with the Botrytis.

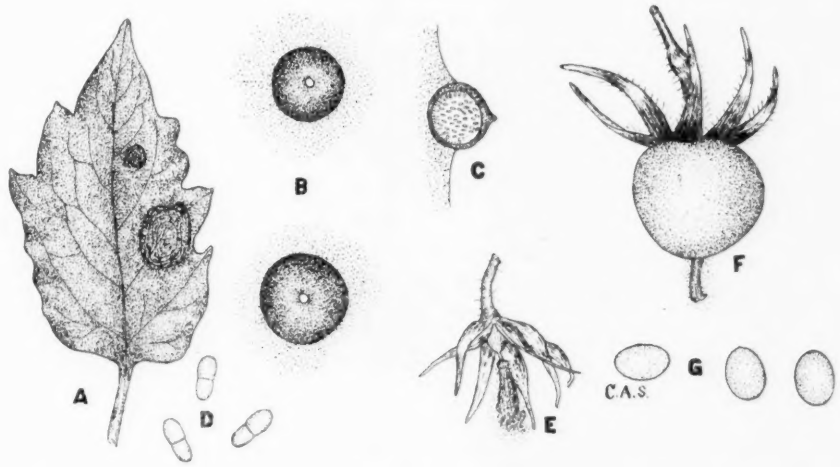

FIG. 1. *A*, Leaf of tomato showing spots produced by *Ascochyta Lycopersici*. $\frac{2}{3}$ natural size. *B*, Pycnidia of *A. Lycopersici*. *C*, Section of pycnidium of *A. Lycopersici*. *D*, Spores of *A. Lycopersici*. *E* and *F*, Dead corolla attacked by Botrytis clinging to young fruit. *G*, Spores of *Botrytis* sp.

When the spores from pure cultures were applied to the roughened blossom-ends of fruits and the fruits kept under moist conditions, the typical rot was produced. When smooth tomato fruits were treated in the same manner, no rot was produced. When smooth fruits were punctured with a sterilized needle and subjected to the same treatment, the typical rot was produced.

These two diseases, the one having symptoms similar to the early blight of the tomato and potato, and the latter producing symptoms practically the same as the well-known blossom-end-rot, serve to demonstrate the fact that symptoms are not always reliable for diagnostic purposes. Many of the apparently contradictory statements in our literature are no doubt

due to this cause. It is also very probable that many minor causes of diseases have been overlooked because producing symptoms similar to those associated with common and well-known diseases.

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PHYTOPATHOLOGICAL NOTES

A convenient, little-known method of making micro-mounts of fungi. The outline here given is a modified method of Winter. It has proved so useful and appears to be so little known that it seems worth while to direct attention to it.

As described by Gaillard in *Le Genere Meliola*, 1892, p. 13, the procedure is as follows: a drop of celloidin solution is placed on the fungus, allowed to dry, then lifted off, bearing the fungus with it. He recommends celloidin solution of the following composition:

Celloidin	4 g.
Alcohol	10 g.
Ether	32 g.
Castor oil	2 g.
Lactic acid	2 g.

He lifts the celloidin film with forceps to a slide then dissolves the celloidin in ether-alcohol.

Alcohol	10 g.
Ether	32 g.

The fungus is then mounted in glycerine jelly. In my personal experience, involving nearly 10,000 mounts, mostly species of Meliola, I have modified the formula by omitting the oil and acid. As soon as the edges curl I find it entirely practicable to lift the celloidin film to a slide, then dehydrate by flushing a few times, usually only twice, with absolute alcohol, then with xylol, after which the mount can be made permanent in xylol-balsam. This procedure eliminates dissolving celloidin film, as recommended by Gaillard, and leaves the fungus permanently encased in the celloidin, which so far as I have been able to observe is no disadvantage.

With all superficial fungi which need no staining the above method serves. It is particularly useful with Meliola, the Microthyriaceae, Perisporiaceae, Torulas, Capnodiums, and so forth, also for the study of natural spore grouping of such objects as the rusts, Moniliales, and so forth.

Good mounts may also be made of the powdery mildews, vastly better mounts than are secured by the usual methods; but still better preparations may be made by applying some suitable stain, as bismarck brown

or gentian violet, to the fungus upon the leaf, washing off superfluous stain, dehydrating, then proceeding as above.

The method also has been found serviceable for the study of colonies on agar. Here it is best to let the medium become dry, then proceed as above, but when occasion demands, colonies can be lifted from the moist agar; in such event, however, extra precaution must be observed in dehydration.

Accidentally I have frequently included superficial algae, liverworts, and even mosses. Such excellent mounts have been secured as to indicate the utility of the method for these groups also.

In practice I have a dropping bottle of 4 per cent celloidin on my table. Drops may be placed rapidly on a number of colonies, and in about five minutes the films are ready to transfer to slides. Alcohol and xylol are successively applied from dropping bottles. Any cloudiness, of course, indicates imperfect dehydration or water from some source. In this way it is possible to make in a very short time a large number of wonderfully good permanent preparations, which preserve the natural position of all parts of the fungus, spores on their conidiophores or mycelium, in natural order.

F. L. STEVENS

A root disease of prunes. During the summer of 1915, a peculiar prune disease appeared in the western part of the Snake River valley in Idaho. In the early part of the season the trees were apparently normal; they blossomed and set fruit, and had produced from six to ten inches of new growth, when they suddenly wilted and died. The final collapse usually came so rapidly that both leaves and fruit remained clinging to the branches. In some cases dying proceeded more slowly and was characterized by dropping of the fruit and by yellowing and dropping of the leaves.

Examinations of the roots of trees which had died rapidly showed that the entire root systems were dead; while examinations of roots from trees which had died more slowly showed that their root systems were not entirely destroyed. A study of those which were partly dead indicated plainly that death had proceeded from the ends of the roots toward the crowns and was not due to the action of parasites. The sap from diseased trees had a peculiar, sour odor, from which the local name "sour sap" was probably derived.

An investigation of a large number of prune orchards brought out the fact that two- and three-years-old trees seldom died of this disease. These trees, having had a small amount of leaf surface during the previous year, did not draw heavily upon soil moisture, so sufficient moisture was left

to keep them alive during the winter. Most of the three-years-old trees that died had been grown in orchards that had been intercropped during the previous season, and had therefore shared the soil moisture with other plants.

By far the largest number of trees which died were four years old. Having been more plentifully supplied with foliage these trees had drawn more heavily upon soil moisture. Cultivation had been valuable in conserving such moisture as was in the soil, but it had also killed the surface roots. The trees, therefore, could not take advantage of light rains or irrigations that did not penetrate deeply. Older trees which were not cultivated did not suffer so severely.

Most orchards showing this type of injury had received an insufficient supply of water during the preceding fall. The winter was cold and open, permitting a large loss of soil moisture. The light showers which fell early in the spring moistened the surface soil and probably helped to save the older trees which had not been cultivated and whose roots came near the surface. Where the cultivation had been deep, the rain could not penetrate to a depth where it could be reached by the roots.

That orchard which had by far the highest percentage of "sour sap" was on well-drained soil. It had been deeply cultivated and had received no irrigation whatever during the previous year.

Although most of the prune trees in the orchards studied were purchased as "peach grafted," water sprouts from these stocks indicate that they differ greatly. It is quite possible that differences in the resistance of these stocks to drought account for the occasional tree which has survived while trees about it have succumbed.

It was quite evident that the lack of moisture during the preceding fall and winter had caused the smaller roots to dry out and die. In the spring when the water was turned on and stored food became available, the bud began to swell, blossoms were produced, fruit set, and the leaves unfolded. The added leaf surface, the formation of fruit, and the increasing dryness of the air, made increasing demands for water, which the dead and decaying roots were unable to supply, and death resulted.

MINA A. WILLIS

Preliminary note on the occurrence of Peridermium balsameum in Washington. During the summer of 1914, while working with the Forest Service in the Cascade Mountains (in the vicinity of Darrington, Snohomish County), the writer's attention was attracted by a white rust on the lower surfaces of the needles of white fir (*Abies amablis*) seedlings. Specimens were collected, but on account of lack of facilities were ruined.

The following summer the same locality was visited and the rust again

found. Samples were sent to Prof. J. C. Arthur, who was kind enough to identify it. It was provisionally referred to *Peridermium pseudo-balsameum* (D. and H.) Arth., but owing to the immaturity of the material and the consequent absence of spores, it could not be identified with any great degree of certainty.

In September of the same year (1915), while in the foothills of the Olympic Mountains (in the vicinity of Port Angeles, Clallam County), the rust was found very abundantly on the seedlings of grand fir (*Abies*

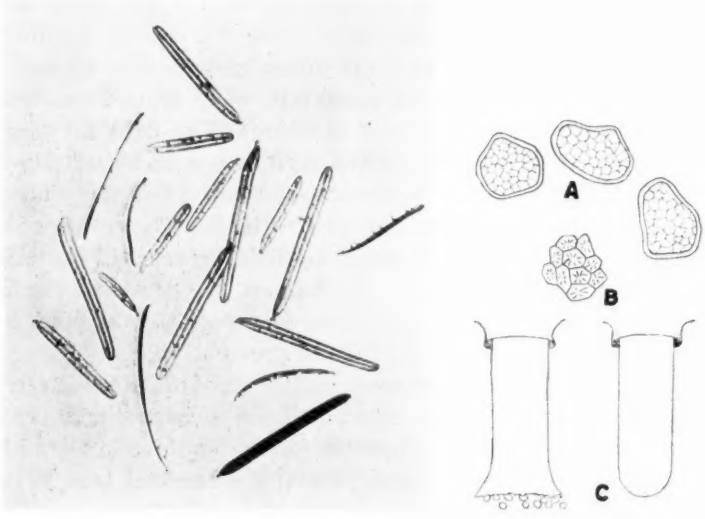

FIG. 1. Needles of *Abies grandis* infected with *Peridermium balsameum* Peck. The aecid a are evident on the lower surface of the leaves.

FIG. 2. *A*, Spores of *Peridermium balsameum* Peck; *B*, A portion of the aecidium wall showing the cellular appearance; *C*, An open and closed aecidium.

grandis). Some of this material was also sent to Professor Arthur. The specimens were older and contained abundant spores. It was identified as *Peridermium balsameum* Peck.[1] The former samples were also referred to this species.

The rust has also since been found by E. J. Hanzlick in approximately the central portion of Mason County, making it extensively distributed throughout western Washington.

The white, elongated aecia are found on the lower surfaces of the needles, as shown in figure 1. Whether the affected leaves are deciduous

[1] Arthur, J. C., and Kern, F. D. North American species of Peridermium. Bul. Torr. Bot. Club **33**: 403–438. 30 Au 1906.

or not could not be ascertained. The injury is not very evident, yet when a seedling is badly infected, as were a great many in the Port Angeles region, the leaves have a pale yellow appearance, especially immediately above the fruiting bodies.

The spores are more or less irregular in shape (fig. 2, a), measuring 19.2 to 21.6 by 24 to 28 μ. The cups open at the free end, giving the appearance shown in figure 2, c. The wall of the cup has a decided cellular structure (fig. 2, b).

The difference between *Peridermium pseudo-balsameum* and *Peridermium balsameum* is but slight, the only difference being that the former has slightly larger and thicker-walled spores. Both species are supposed to be alternate forms of rusts on ferns.

This is the first record of *Peridermium balsameum* west of the Mississippi Valley. Its abundance and perhaps economic bearing on various species of Abies makes it of particular interest.

HENRY SCHMITZ

The wintering of Coleosporium solidaginis. Ever since it was noticed that *Puccinia graminis* was wide-spread in countries where there was no barberry, attempts have been made to explain how such heteroecious rusts wintered when one or the other of the alternate hosts was absent. Besides the grain rusts, a number of heteroecious rusts are found in regions where their alternate host is not present. *Coleosporium solidaginis* (Schw.) Thüm. is such a one. This rust is found in its uredo- and teleutospore stages on species of Aster and Solidago and is distributed throughout the United States and Canada. *Peridermium acicolum* Under. & Earle, the aecidial stage, according to Arthur is found upon *Pinus rigida* in Connecticut, Massachusetts, New Jersey, and New York. Orton and Adams, besides finding it upon *Pinus rigida* in Pennsylvania, also report it upon *Pinus pungens.* Hedgcock and Wier and Hubert have recently shown that *Peridermium montanum* Arth. & Kern upon *Pinus contorta* in the West will produce this rust upon Solidago and is in consequence synonymous with *Peridermium acicolum.* The aecidial stage of the rust is thus limited in the eastern states to *Pinus rigida* and *Pinus pungens* and in the western states to *Pinus contorta.* The regions where these aecidial hosts are not found still have the rust on Aster and Solidago in great abundance.

On February 13, 1915, while on a collecting trip, my attention was called to a rust on *Solidago* sp. by Mr. Alfred Povah. This proved to be *Coleosporium solidaginis.* The unopen pustules of the rust were scattered over the rosette leaves of the Solidago, which was growing in a low, marshy place. The spores from these pustules did not germinate

when placed in distilled water. On February 27, a few open pustules were obtained from some of these plants, and these gave a fair germination in distilled water. On April 17, pustules were found upon the rosette leaves of a Solidago in a similar marshy place in another locality. On May 6, open pustules were found upon the rosette leaves, and unopen pustules were present on the leaves of the stem, which had been formed by this time.

On January 4 of the present year (1916), infected rosettes of a Solidago were again found in a marshy locality. The spores from the pustules on the leaves of these plants gave no germination in distilled water. On January 8, a few open pustules were found and these had spores which gave a fair germination in distilled water. On January 21, three plants with pustules upon some of the leaves of the rosette were brought in and the infected leaves were cut off. Pustules appeared upon the other rosette leaves from day to day and as fast as these appeared the leaf was cut off. By February 11, the wintered rosette leaves were all cut off. The new leaves which developed did not produce pustules at this time or later. At this time other infected plants were brought in and free-hand sections were made of the different parts of the plant. These were treated with chloral hydrate and iodine to make the mycelium stand out. Mycelium was found only in the rosette leaves and in these only in limited areas.

From this it appears the *Coleosporium solidaginis* winters in the rosette leaves of *Solidago* sp., both as mycelium and as uredospores, and that in regions where the alternate host is not found the uredospores formed from this wintered mycelium will serve as the source of infection in the spring.

E. B. MAINS

Successful inoculations of Larix occidentalis and Larix europea with Melampsora bigelowii. Collections of leaves of *Salix bebbiana* Sarg. bearing telial sori of *Melampsora bigelowii* Thüm. were made in Pattee Canyon near Missoula, Montana, on March 12, 1916. On April 15, 1916, freshly germinating teliosporic material of *Melamspora bigelowii* was sown on one seedling of *Larix occidentalis* Nutt. in the greenhouse at Missoula. Pycnia appeared on May 2 and aecia on May 5, resulting in a heavy infection of all the young needles subjected to the inoculation. Control plants remained normal.

On April 18, 1916, an inoculation of two seedlings of *Larix europea* was made with teliospores of *M. bigelowii* on *Salix cordata mackenzieana* Hook., collected at Priest River, Idaho, April 13, 1916. Pycnia appeared on May 5 and aecia on May 8, giving a medium infection of those needles subjected to the inoculation. The aecial stage developing on the two

larches was found upon examination to be identical. All inoculations were isolated by the use of celluloid cylinders and cotton plugs at the greenhouse of the Office of Investigations in Forest Pathology, Department of Agriculture, at Missoula, Montana. Control plants remained normal.

JAMES R. WEIR
ERNEST E. HUBERT

A successful inoculation of Abies lasiocarpa with Pucciniastrum pustulatum. A collection of over-wintered leaves of *Epilobium angustifolium* L. infected with *Pucciniastrum pustulatum* (Pers.) Diet. was made on April 13, 1916, at Priest River, Idaho. The leaves were kept in a moist chamber for three days in the greenhouse at Missoula, Montana, and then suspended over young needles of one small tree of *Abies lasiocarpa* (Hook) Nutt. The inoculation was isolated by means of a celluloid cylinder and cotton plugs. The needles and inoculating material were kept moist by water sprayed with an atomizer. On May 14, several pycnia appeared on the younger needles at the tips of the branches, and on May 17 almost all the young needles bore a large number of aecia. Control plants remained normal.

JAMES R. WEIR
ERNEST E. HUBERT

Errata. The attention of workers with the Fusaria is directed to the following important errors in a memoir[1] on Fusaria of potatoes.

Page 92, omit the word *diffusum* and move page reference to species *effusum*.

Page 162, seventh line, and page 163, eighth line, for 3.7 read 1.7.

Page 166, next to last line, for *diffusum* read *effusum*.

Page 180, second line, should read: *F. arthrosporioides*, Ireland.

Pages 214 and 216, first word of the description, for *microconidia* read *macroconidia*.

C. D. SHERBAKOFF

Personals. Dr. Arthur Harmount Graves, formerly assistant professor of botany in the Sheffield Scientific School of Yale University and instructor in forest botany in the Yale Forest School, has been appointed associate professor of biology in the new Connecticut College for Women, at New London, Connecticut. Doctor Graves will have charge of the instruction in botany.

[1] Sherbakoff, C. D. Fusaria of Potatoes. Cornell Univ. Agr. Exp. Sta. Mem. 6: 85–270, 51 fig., 7 col. pl. 1915.

Dr. G. L. Peltier, formerly associate plant pathologist of the Illinois Agricultural Experiment Station, has accepted the position of pathologist of the Alabama Experiment Station.

Mr. J. R. Winston, formerly plant pathologist of the Hood River branch station of the Oregon Experiment Station, has been appointed assistant pathologist in fruit disease investigations, Department of Agriculture. He will assist Dr. H. R. Fulton in his investigations of the diseases of subtropical fruits.

Mr. Fred C. Meier, a student in the Laboratory of Cryptogamic Botany of Harvard University, has been appointed an agent of the Department of Agriculture for a temporary period of three months, beginning June 1, and will be engaged in the investigation of diseases of watermelons.

Recent appointments to the Office of Investigations in Forest Pathology, Department of Agriculture, are as follows: Samuel B. Detwiler, formerly field superintendent of the Pennsylvania Chestnut Tree Blight Commission, has been appointed forest inspector in charge of field work on the white pine blister rust.

Reginald H. Colley, lately assistant professor of botany in Dartmouth College, and Minnie W. Taylor, lately assistant in botany, in Brown University, have been appointed agents to assist Dr. Perley Spaulding in research on the white pine blister rust.

Paul V. Siggers, lately a graduate student in botany in the University of Michigan, and Gilbert T. Posey, research assistant in botany at the Oregon Experiment Station, have been appointed scientific assistants to Mr. Detwiler.

George L. Barrus and Norton M. Goodyear, recently engaged in commercial forestry, have been appointed agents also assisting Mr. Detwiler.

In addition to these more or less permanent appointments, about forty field agents have been appointed for temporary periods to work on the white pine blister rust in cooperation with various state officials. Field work on the white pine blister rust east of Ohio is organized under the general direction of Mr. Detwiler; west of and including Ohio, under the general direction of Mr. Roy G. Pierce.

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

April to May, 1916

Adams, J. F. Internal Uredinia. Mycologia **8**, no. 3: 181–182, pl. 186. May, 1916.

American Phytopathological Society. Report of the seventh annual meeting. Phytopathology **6**, no. 2: 209–218. April, 1916.

Anderson, Harry Warren. A new leaf spot of Viola cucullata. Proc. Indiana Acad. Sci. **1914**: 187–190. 1915.

Colletotrichum sp.

Arthur, Joseph Charles. Cultures of Uredineae in 1915. Mycologia **8**, no. 3: 125–141. May, 1916

——— Some large botanical problems. Proc. Indiana Acad. Sci. **1914**: 267–271. 1915.

Soil fungus attacking vegetables; soil fungi attacking forage crops; soil fungi attacking grains; diseases not associated with the soil; poisonous plants and molds.

——— Uredinales of Porto Rico based on collections by F. L. Stevens. Mycologia **8**, no. 1: 16–33. January, 1916.

Ashby, S. F. Report of the microbiologist. Ann. Rpt. Dept. Agr. Jamaica [**1914**]/**15**: 29–31. 1915.

Barrett, James Theophilus. Apricot fruit spots. Univ. California Jour. Agr. **3**, no. 8: 346–349. May, 1916.

Brown rust (*Puccinia prunispinosæ*); Coryneum fruit spot (*Coryneum beijerinkii*); scab (*Cladosporium carpophilum*).

Bartholomew, Elbert T. Observations on the fern rust Hyalopsora Polypodii. Bul. Torrey Bot. Club **43**, no. 4: 195–199, 2 fig. April, 1916.

Berthet, J. Arthaud. Inimigos da mandioca. Bol. Agr. [São Paulo] **17**, no. 1: 37–38. Janeiro, 1916.

Fusarium.

——— Molestia das cebolas. Bol. Agr. [São Paulo] **16**, no. 7: 592–593. Julho, 1915.

Macrosporium sarcinula Berk.

——— Uma pestalozzia das pereiras. Bol. Agr. [São Paulo] **16**, no. 12: 1051–1052. Dezembro, 1915.

Boyce, J. S. A note on Cronartium pyriforme. Phytopathology **6**, no. 2: 202–203. April, 1916.

[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals. All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

Brooks, A. B. Chestnut blight and its control in West Virginia. State Crop Pest Com. West Virginia 1st Bien. Rpt. **1913/14:** 90–94. 1916.

Also in Bul. State Crop Pest Com. West Virginia no. 2.

——— Report of chestnut blight eradication. State Crop Pest Com. West Virginia 1st Bien. Rpt. **1913/14:** 50–61. 1914.

Chapman, George H. Effect of colored light on the mosaic disease of tobacco. Science n. s. **43,** no. 1111: 537–538. April 14, 1916.

Chase, W. W. The principal parasites of the peach. Georgia State Bd. Ent. Bul. 43: 5–39, illus., 14 pl. 1916.

Brown rot, p. 22–26; crown gall, p. 29–30; scab, p. 30–31; leaf curl, p. 33–35; nematode worm (*Heterodera radicicola*), p. 35.

Collins, James Franklin. Cutting and trimming blocks of wood. Phytopathology **6,** no. 2: 200–201. April, 1916.

——— Marking laboratory apparatus. Phytopathology **6,** no. 2: 198–199. April, 1916.

——— Marking trees in the field. Phytopathology **6,** no. 2: 199–200. April, 1916.

——— Polishing sections of wood. Phytopathology **6,** no. 2: 201. April, 1916.

Cook, Dewain. Plums that we already have and plums that are on the way. Minnesota Hort. **44,** no. 4: 148–151. April, 1916.

The brown rot (Monilia) a controlling factor.

Cook, Melville Thurston. Common diseases of beans. New Jersey Agr. Expt. Sta. Circ. 50, 4 p. 1915.

——— Common diseases of the grape. New Jersey Agr. Expt. Sta. Circ. 55, 8 p., 2 fig. 1916.

——— and **Helyar, John P.** Diseases of grains and forage crops. New Jersey Agr. Expt. Sta. Circ. 51, 8 p. 1915.

Supersedes Circ. 36, "Grain smuts: their causes and treatments."

Coons, George Herbert, and **Levin, Ezra.** The Septoria leaf spot disease of celery or celery blight. Michigan Agr. Expt. Sta. Spec. Bul. 77, 8 p., 9 fig. 1916.

Crabill, Charles Harvey. The frog-eye leaf spot of apples. Virginia Agr. Expt. Sta. Bul. 209, 16 p., 5 fig. 1915.

References, p. 16.

Sphæropsis malorum.

——— Note on apple root-rot in Virginia. Phytopathology **6,** no. 2: 159–161, fig. 1. April, 1916.

Trichoderma koeningi.

Dash, J. Sydney. Report . . . . on the entomological and mycological work carried out during . . . . the season . . . . Rpt. Dept. Agr. Barbados **1913/14:** 37–54, 1915; **1914/15:** 38–44, 1916.

Fungoid attacks reported or observed, 1913/14, p. 43–45; plant diseases of the year, 1914/15, p. 43–44.

Dodge, Bernard Ogilvie. Fungi producing heart-rot of apple trees. Mycologia **8,** no. 1: 5–15, pl. 173–176. January, 1916.

Polyporus admirabilis; Spongipellis galactinus; S. fissilis.

Doolittle, S. P. A new infectious mosaic disease of cucumber. Phytopathology **6,** no. 2: 145–147. April, 1916.

Organism undetermined.

Edgerton, Claude Wilbur. The control of bean anthracnose or pod spot disease. Louisiana Agr. Expt. Sta. Circ. 16, 4 p., 2 fig. 1916.

——— and **Garrett, J. B.** Citrus canker. Louisiana Agr. Expt. Sta. Circ. 15, 11 p., 3 fig. 1916.

Edgerton, Claude Wilbur and **Moreland, C. C.** Experiments on varietal resistance to the bean and cotton anthracnose diseases. Louisiana Agr. Expt. Sta. Bul. 155, 24 p., illus. 1916.

Erwin, Arthur Thomas. Late potato blight in Iowa. Iowa Agr. Expt. Sta. Bul. 163: 287–305, 8 fig. 1916.

Fawcett, Howard S. Brown rot control. California Citrograph **1,** no. 7: **17,** 2 fig. April, 1916.

——— Fighting a fungus, Pythiacystis citrophthora, in the citrus orchards. Univ. California Jour. Agr. **3,** no. 8: 339–343, 3 fig. May, 1916.

——— A spotting of citrus fruits due to the action of oil liberated from the rind. California Agr. Expt. Sta. Bul. 266: 261–269, 2 fig. 1916.

Giddings, Nahum James. Rust of apple. State Crop Pest Com. West Virginia 1st Bien. Rpt. **1913/14:** 85–89. 1914.

Also in Bul. State Crop Pest Com. West Virginia no. 2.

Gilbert, William Williams. Cucumber mosaic disease. Phytopathology **6,** no 2: 143–144, pl. 5. April, 1916.

Organism undetermined.

Gloyer, Walter Oscar, and **Fulton, B. B.** Tree crickets as carriers of Leptosphæria coniothyrium (Fckl.) Sacc. and other fungi. New York State Agr. Expt. Sta. Tech. Bul. 50, 22 p., 4 pl. 1916.

Literature cited, p. 20–22.

Grossenbacher, John Gasser. Improper irrigation—bark diseases [of citrus]. Florida Grower **13,** no. 15: 18–19. April 8, 1916.

——— Sour scab of citrus in Florida, and its prevention. Phytopathology **6,** no. 2: 127–142, 4 fig. April, 1916.

Cladosporium Citri, at most, only partially responsible.

Hawkins, Lon Adrian. Effect of certain species of Fusarium on the composition of the potato tuber. Jour. Agr. Research **6,** no. 5: 183–196. May 1, 1916.

Literature cited, p. 196.

Howitt, J. Eaton, and **McCubbin, W. A.** An outbreak of white pine blister rust in Ontario. Phytopathology **6,** no. 2: 182–185. April, 1916.

Cronartium ribicola.

——— and **Stone, Roland Elisha.** A troublesome disease of winter tomatoes. Phytopathology **6,** no. 2: 162–166. April, 1916.

Little known as to cause of the disease.

Jagger, Ivan C. Experiments with the cucumber mosaic disease. Phytopathology **6,** no. 2: 148–151. April, 1916.

——— Vegetable diseases. West. New York Hort. Soc. Proc. 61st Ann. Meeting **1916:** 175–177. [1916.]

Johnson, James. Resistance in tobacco to the root-rot disease. Phytopathology **6,** no. 2: 167–181, 6 fig. April, 1916.

Thielavia basicola Zopf.

Jones, Paul R. Combination spraying for insect pests and fungus. Better Fruit **10,** no. 9: 7–9, fig. 53–54. March, 1916.

Kew—Royal Gardens. Kew pathological laboratory. Phytopathology **6,** no. 2: 204. April, 1916.

Notice of establishment. A. D. Cotton in charge.

Long, William Henry. Note on western red rot in Pinus ponderosa. Mycologia **8,** no. 3: 178–180. May, 1916.

Lourena, B. A ferrugem das batatas. Bol. Agr. [São Paulo] **15,** no. 1: 27–30. Janeiro, 1914.
Phytophthora infestans.

Ludwig, C. A. Continuous rust propagation without sexual reproduction. Proc. Indiana Acad. Sci. **1914:** 219–230. 1915.
Bibliographical footnotes.

McMurphy, James. A Phytophthora on oats Science n. s. **43,** no. 1111: 534. April 14, 1916.

Martin, George W. Common diseases of the pear. New Jersey Agr. Expt. Sta. Circ. 52, 12 p., 6 fig. 1915.

Maxwell, R. B. Fungus diseases of trees. Amer. Forestry **22,** no. 267: 161–163, illus. March, 1916.

Meier, F. C. Watermelon stem-end rot [Preliminary paper.] Jour. Agr. Research, **6,** no. 4: 149–152, pl. 17. April 24, 1916.
Diplodia sp.

Meinecke, Emilio Pepe Michael. Forest pathology in forest regulation. U. S. Dept. Agr. Bul. 275, 62 p. 1916.

Melchers, Leo Edward. Smuts of grain and forage crops in Kansas. Kansas Agr. Expt. Sta. Bul. 210, 38 p, 20 fig. 1916.

Newell, Wilmon. The port and railway inspection work of the state plant board of Florida. Florida Grower **13,** no. 22: 8–9. May 27. 1916.

Nowell, William. The internal disease of cotton bolls. Agr. News [Barbados] **15,** no. 364: 126–127. April 8, 1916.

O'Neal, Claude E. Some species of Nummularia common in Indiana. Proc. Indiana Acad. Sci. **1914:** 235–248, pl. 1–4. 1915.

Orton, William Allen. Potato seed inspection and certification. 7th Ann. Rpt. Com. Agr. State Vermont **1915:** 56–64. 1915.

Pan-American Scientific Congress. Resolution in regard to plant protection adopted January 8, 1916. Phytopathology **6,** no. 2: 204. April, 1916.

Peltier, George Leo. Sclerotium rolfsii in Illinois. Phytopathology **6,** no. 2: 201–202. April, 1916.
On perennials.

Pickett, Bethel Stewart, Watkins, O. S., and others. Field experiments in spraying apple orchards. Illinois Agr. Expt. Sta. Bul. 185, 212 p., pl. 1916.

Pipal, Francis John. Oat smut in Indiana. Proc. Indiana Acad. Sci. **1914:** 191–196. 1915.

Pool, Venus Worrell, and **McKay, Marion B.** Climatic conditions as related to Cercospora beticola. Jour. Agr. Research **6,** no. 1: 21–60, 10 fig., pl. 3–4. April, 3, 1916.

Pratt, O. A. A western field rot of the Irish potato tuber caused by Fusarium radicicola. Jour. Agr. Research **6,** no. 9: 297–310, pl. 34–37. May, 29, 1916.

Ramsay, Glen B. The genus Rosellinia in Indiana. Proc. Indiana Acad. Sci. **1914:** 251–263, pl. 1–2. 1915.

Reddick, Donald. Botany and plant diseases. Serious diseases of the season. West. New York Hort. Soc. Proc. 61st Ann. Meeting **1916:** 94–98. [1916.]
Discussion, p. 99–105.

——— Sulfur paste as a spray for peaches. Phytopathology **6,** no. 2: 206–207. April, 1916.

São Paulo. Secretaria da Agricultura, Commercio e Obras Publicas. Oidium. Bol. Agr. [Sao Paulo] **16,** no. 12: 1017–1022, 3 fig. Dezembro, 1915.

Schoene, W. J. Conference on pear blight. Amer. Fruit-Grower **May:** 13–14. 1916.

Contains abstract of address by M. B. Waite.

——— Court decision upholding the cedar rust law. 10th Rpt. State Ent. and Plant Path. Virginia **1914/15:** 16–29. 1916.

Opinion regarding constitutionality of cedar rust law. By E. S. Turner, p. 21–29.

Shaw, Harry Berry. The sugar-beet nematode and its control. Sugar **17,** no. 2: 31–35, pl. 1–6, February; no. 3: 56–60, fig. 1, March; no. 4: 58–61, April; no. 5: 58–63, fig. 2–3, pl. 8–10, May; no. 6: 58–60, pl. 7, June; no. 7: 55–58, July; no. 8: 51–53, August; no. 9: 54–55, September. 1915.

Also reprinted with the exception of pl. 2 and 10. Reprint contains an additional plate (pl. 6).

Smith, Clayton Orville. The control of crown gall, or root knot. Pacific Rural Press **91,** no. 15: 441, 458–459, 2 fig. April 8, 1916.

——— Preliminary studies on the resistance of Prunus to artificial inoculation with Bacterium tumefaciens. Phytopathology **6,** no. 2: 186–194, pl. 6. April, 1916.

Smith, Erwin Frink. Crowngall studies showing changes in plant structures due to a changed stimulus. [A preliminary paper.] Jour. Agr. Research **6,** no. 4: 179–182, pl. 18–23. April 24, 1916.

Spaulding, Perley. Foresters have a vital interest in the white pine blister rust. Proc. Soc. Amer. Foresters **11,** no. 1: 40–47. January, 1916.

List of publications cited, p. 46–47.

——— The white-pine blister rust situation. Amer. Forestry **22,** no. 267: 137–138, 4 fig. March, 1916.

Starcher, G. C. A stone-fruit spray made from hydrated-lime and sulphur. Virginia Agr. Expt. Sta. Bul. 210, 14 p. 1916.

Stakman, Elvin Charles. Spraying plums for brown rot. Minnesota Hort. **44,** no. 4: 148–151. April, 1916.

Discussion, p. 151–155.

Sclerotinia cinerea (Bon.) Wor.

——— and **Tolaas, A. G.** Fruit and vegetable diseases and their control. Minnesota Agr. Expt. Sta. Bul. 153, 67 p., 32 fig. 1916.

——— ——— Potato diseases and their control. Minnesota Agr. Expt. Sta. Bul. 158, 47 p., 28 fig. 1916.

Stevens, Neil Everett. Recovery of a chestnut tree from a lightning stroke. Phytopathology **6,** no. 2: 204–206. April, 1916.

Stewart, Vern Bonham. The leaf blotch of horse-chestnut. New York (Cornell) Agr. Expt. Sta. Bul. 371: 411–419, fig. 85–92, pl. 10 (col.). 1916.

Guignardia Æsculi

——— and **Leonard, M.D.** Further studies in the rôle of insects in the dissemination of fire blight bacteria. Phytopathology **6,** no. 2: 152–158. April, 1916.

Swingle, Mrs. Maude (Kellerman). Successful long-distance shipment of citrus pollen. Science n. s. **42,** no. 1081: 375–377. September 17, 1915.

"It is likely . . . . . that in most cases pollen shipped in vacuum tubes could be sent without danger of carrying plant diseases or insect pests."

Travelbee, H. C. Correlation of certain long-cycled and short-cycled rusts. Proc. Indiana Acad. Sci. **1914:** 231–234. 1915.

U. S. Department of Agriculture. Federal Horticultural Board. Letter of information no. 20, 10 p. October 16, 1915.

U. S. Department of Agriculture. Federal Horticultural Board. Service and regulatory announcements. December, 1915: 91–99, January 29, 1916; January, 1916: 1–13, March 1, 1916; February, 1916: 15–30, March 24, 1916; March, 1916: 31–43, April 29, 1916.

Weir, James Robert. Hypoderma deformans, an undescribed needle fungus of the western yellow pine. Jour. Agr. Research **6,** no. 8: 277–288, 4 fig., pl. 22. May 22, 1916.

West Virginia. Laws, Statutes, etc. Proposed crop pest law to supersede the present statutes. State Crop Pest Com. West Virginia 1st Bien. Rpt. **1913/14:** 123–132. 1914.

——— ——— State crop pest law. Rules and regulations of the commission. Act of 1913. State Crop Pest Com. West Virginia 1st Bien. Rpt. **1913/14:** 69–75. 1914.

Also in Bul. State Crop Pest Com. West Virginia no. 2.

West Virginia State Crop Pest Commission. Rules and regulations of the West Virginia state crop pest commission. State Crop Pest Com. West Virginia 1st Bien. Rpt. **1913/14:** 76–81. 1914.

Also in Bul. State Crop Pest Com. West Virginia no. 1.

Wilcox, Edwin Mead. Potato diseases and disease resistance. 46th Ann. Rpt. Nebraska Hort. Soc. **1915:** 153–163, illus. 1915.

Discussion, p. 159–163.

Winfield, T. A. Lagrima and its relation to foot-rot. Florida Grower **13,** no. 13: 10–11, 21. March 25, 1916.

Wolf, Frederick Adolf. Citrus canker. Jour. Agr. Research **6,** no. 2: 69–100, 8 fig., pl. 9–11. April 10, 1916.

Literature cited, p. 98–99.

Young, Esther. Studies in Porto Rican parasitic fungi—II. Mycologia **8,** no. 1: 42–46. January, 1916.

[PHYTOPATHOLOGY, for June, 1916 (**3:** 225–319, Pls. VII–VIII), was issued June 3, 1916.